DECISION MAKING IN PROFESSIONAL SOCCER: FROM MATCH-PLAY TO TRAINING

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Abstract

The aims in the current programme of research were to assess and analyse the perceptual-cognitive load of professional soccer players during match-play, training and coaching. In Chapter 2, an attempt was made to quantify and analyse the frequency, type and success of decisions executed as actions in professional soccer players during professional soccer matches in the English Premier League (EPL), as well as investigating the effect of positional role, time and phase of play. In Chapter 3, an attempt was made to examine the types of practice activities that coaches have youth soccer players engage in England to assess their opportunities for decision making. Additionally, practice specificity in relation to match-play was measured including; type of pitch surface, directional orientation and the size of the practice area used. Finally, Chapter 4 attempted to examine the effectiveness of a typical coaching course in changing coach behaviour related to designing practice so as to increase player decision making during that activity and, subsequently, player skill acquisition and transfer to match-play. In Chapter 2, soccer players executed 2,103 (*SD* = 149) actions per match, averaging 21.8 (*SD* = 1.5) actions per minute. They had 60 (*SD* = 20) ball possessions per match, of which 75% were successfully executed. More actions were executed in the first half (22.3 actions per minute (*SD* = 1.7)) compared to the second half (21.1 actions per minute (*SD* = 1.9)). In Chapter 3, the coaching sessions contained 58.7 (*SD* = 19.7%) of decision-making activity, 20.5 (*SD* = 18.5%) that was not, and 20.8 (*SD* = 7.4%) of transition between activities. Greater amounts of decision-making activity were found in child compared with adolescent teams. 96 out of 108 sessions (89%) were performed on artificial surfaces, whereas 12 out of 108 sessions (11%) were on natural grass. 39 out of 108 sessions (36%) were practiced in a quarter of the pitch, 44 out of 108 sessions (41%) were practiced in half of the pitch,

with 25 out of 108 sessions (23%) practiced on a full pitch. In Chapter 4, decision-making activity significantly increased by 18% after compared to before the course, whereas non-decision-making activity significantly decreased by 10%. Coaches cited reasons for this change as their participation on the course, making their training sessions more game-realistic, attempting to develop the decision making of their players, and external reasons, such as the club curriculum. Game footage was analysed for the amount of visual search and success of decision making showing significantly more of these skills in the games after, compared to before the course. The course appears to have led to the coaches increasing the amount of decision making activity they used in their sessions. Across the same time period, the visual scanning and decision making of the players improved significantly. Findings have implications for theory and practice, extending research in the area of perceptual-cognitive expertise and overcoming some of the limitations with previous research.

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Acknowledgments

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Chapter 1

Literature Review

Introduction

Many people seek excellence in all walks of life; however, a very limited amount achieve an expert level of performance and either attain satisfactory performance or drop out. Sport is a domain in which these contrasting fortunes are publicly highlighted. For example, according to Tucker (2015) there are 12,500 players in the English youth academy system in professional football, but only 0.5% of players recruited to clubs at 8 years of age are likely to progress to the adult first team. This is not just prevalent in football, he also suggested that drop-out rates in football are very similar to other sports, such as rugby union, which can lose up to 76% of players between the ages of 13 and 16 years. Therefore, interest in the attainment of expertise has led to researchers in sport examining the factors that set expert performers apart from novices (e.g., Ericsson, 2006). Multiple researchers have attempted to analyse the mechanisms that provide experts with such a high level of knowledge and performance. Research in this domain is important as it allows researchers and the coaching process to understand how individuals improve and gain excellence at different, varying rates (Ericsson, 2006).

Expertise is generally defined as the ability of an individual to consistently demonstrate superior levels of proficiency within a particular domain over an extended time period (Starkes, 1993). Researchers agree that engagement in practice and the accumulation of hours within a specific domain are an important part of becoming an expert performer (Ericsson, Krampe, & Tesch-Romer, 1993; Ericsson & Lehmann, 1996; 2003a; 2006; 2007a; Ercisson & Towne, 2010). An activity termed *deliberate practice* has been highlighted as a key activity in this process. It is engaged in with the intention of improving specific aspects of competition performance and leads to the development of expert performance. The theory has been described and reviewed in

several research articles and book chapters by Ericsson (1996; 2003a; 2006; 2007a; Ericsson et al., 1993; Ericsson & Towne, 2010). The seminal paper published by Ericsson et al. (1993) introduced and provided the first examination of deliberate practice theory across two studies. In Study 1, Ericsson et al. (1993) examined current and past levels of deliberate practice in three groups of adult violinists. The researchers identified the activities constituting deliberate practice and determined the duration of those practices. Violin students from the Music Academy of West Berlin were split into three groups: best violinists, good violinists and music teachers. The 'best violinists' group comprised of 10 violinists nominated by music professors as having the potential for attaining careers as international soloists. The music professors also nominated 10 lesser-skilled 'good violinists' who were selected by matching their gender and age to the best violinists. For the third group 'music teachers', 10 students were recruited from the music education department in the academy. Again, the students were matched by gender and age to those of the other two groups. An additional fourth group took part in the study comprised of middle-aged professional violinists playing in world-class orchestras, who were added in order to provide data on a current expert group. In Study 2, expert pianists and amateur pianists participated in the study (n = 12 per group). The expert pianists were students in another Berlin music academy, whereas the amateur group were external to the academy, but were able to play some classical music and successfully complete a piece by the composer Bach. All participants across both studies were required to retrospectively recall through interviews and diaries the number of hours spent in musical activities between start age in that domain and the current time. The first study found that by 18 years of age the 'best violinists' in the academy and the middle-aged violinists who played in world-class orchestras had accumulated 7,410 and 7,336 hours in solitary deliberate

practice activities, respectively. The solitary practice was guided by music teachers in the academy who met one-to-one with the musicians each week to provide feedback and feedforward information. In comparison, the 'good violinists' had accumulated 5,301 hours in this activity, whereas the music teachers had accumulated only 3,420 hours. The accumulated hours of deliberate practice alone for each of the violinist groups was positively related to their current level of achievement, indicating that performance level is directly related to the amount of deliberate practice. In the second study, they found that expert pianists accumulated 7,606 hours of solitary deliberate practice by 18 years of age, which was significantly more than the 1,606 hours accumulated by the amateur pianists. Again, these results show that accumulated deliberate practice hours are highly related to current performance level in pianists. Findings indicate that there is a clear and direct relationship between the number of hours accumulated in deliberate practice and the level of attainment for expert performers.

Expert performance in sport requires a combination of motor and perceptual-cognitive skills that are likely developed though the accumulation of hours in deliberate practice and other activities. Perceptual-cognitive skill is the ability to identify and acquire environmental information for integration with existing knowledge to facilitate selection of the appropriate response to be executed (Marteniuk, 1976). De Groot (1965) was the first researcher to assess perceptual-cognitive skills in expert performers in his study of master and amateur chess players. He presented both groups (master and amateur) with chess positions for a 2-15 second time lapse and then removed the scene. The chess players were asked to recall and reconstruct the positions of the chess pieces. The master chess players were able to recall and reconstruct the exact locations of the chess pieces and were significantly

better at this task than the amateur chess players. Further research by Simon and Chase (1973) replicated and extended the early work from De Groot (1965). In this study, the researchers had master and novice chess players recall both game-related and randomised configurations of chess pieces on a chessboard. The master chess players were able to reliably recall chess pieces under game-related conditions and more so compared to novices, whereas there were no significant differences between master and novice chess players for the random-test condition. These results provide evidence that master chess players do not have general memory skills of, in this case, randomised chess pieces when compared to novice chess players. However, their ability to reliably recall and reconstruct 15 to 30 chess pieces from structured gameplay reveals that they have an extensive *domain-specific* knowledge base that novices do not possess (Simon & Chase, 1973). This extensive knowledge base was hypothesized to be developed over a prolonged period equating to a decade or more that was termed the ’10-year rule’ (Simon & Chase, 1973). Similarly, findings in the Ericsson et al. (1993) study showed the adult musician participants started in the domain at around 5 years of age, providing some support for the idea that it takes at least 10 years of intensive preparation in order to acquire and attain the complex mechanisms underlying expertise in a specific domain.

In sport, the perceptual-cognitive abilities to anticipate and make quick and accurate decisions are thought to be important for expert performance, such that in some ball sports these components are more likely to differentiate between professional players when compared to physical and physiological factors (Williams & Reilly, 2000). Perceptual-cognitive skills of anticipation (i.e., the ability of an athlete to predict what is likely to happen prior to the event taking place) and decision making (i.e., the ability of the athlete to select and execute appropriate actions within

an event) are deemed essential in team ball sports, such as soccer, due to the pressured time constraints and speed of play (Williams & Burwitz, 1993). The next sections will introduce the perceptual-cognitive adaptations that occur as a result of practice and engagement in a domain. First, the Expert Performance Approach is presented as a framework for the study of expertise.

Expert Performance Approach

Ericsson and Smith (1991) proposed the expert performance approach as a framework for the study of expertise. The Expert Performance Approach contains three stages as illustrated in Figure 1.0.

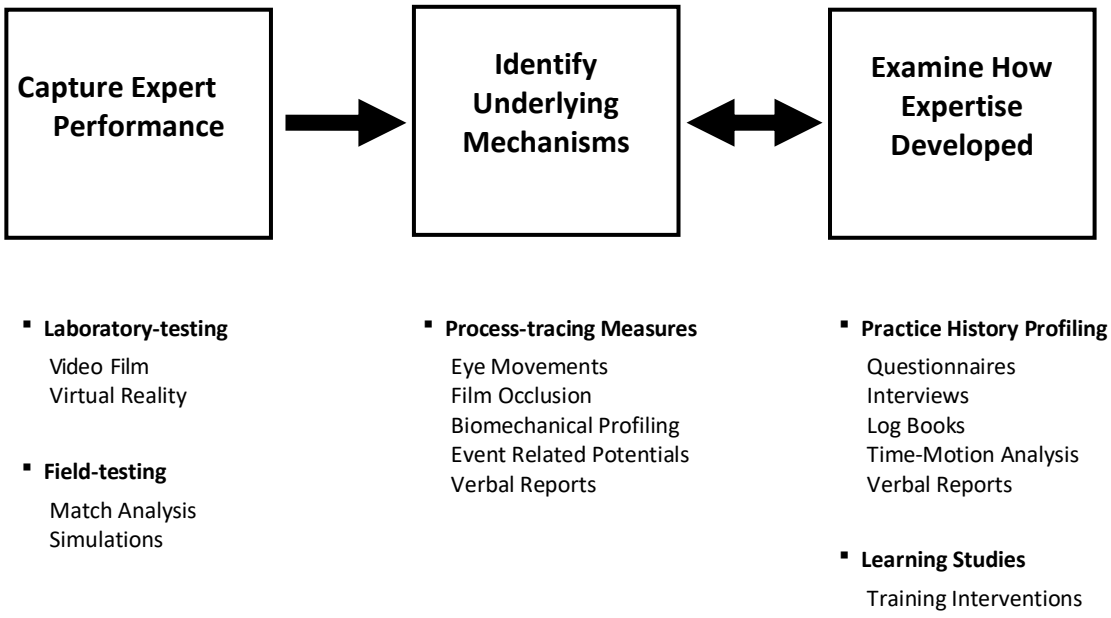

Figure 1.0. An illustration of the expert performance approach and some of the methods and measures that may be used at each stage.

In the first stage, researchers study observable expert performance in order to capture the essence of expertise in the domain and identify the representative tasks that

would allow those skills to be reproduced and tested in the laboratory or field setting. In the second stage, the aim of the approach is to determine the underlying mechanisms that facilitate expert performance on the representative task/s, such as process-tracing measures of eye-movement recordings, verbal protocol analysis, and/or representative task manipulations. Finally, the third stage of the expert performance approach seeks to assess and determine how experts acquire and develop the skills and mechanisms needed to demonstrate superior performance on the task, for example, adaptive learning and acquisition sources. The current thesis will use elements of the Expert Performance Approach framework as a structure for examining decision-making load and expertise in soccer and its acquisition.

Capturing perceptual-cognitive expertise

In the first stage of the Expert Performance Approach, researchers seek to capture observable expert performance in a domain. In order to capture this, well-designed representative tasks that provide effective and reproducible measures of superior performance under standardised laboratory or sometimes field-setting conditions are used. Representative task testing is carried out under controlled situations that replicate the performance environment as closely as possible, in order to identify valid differences between expert and novice performers. Multiple research studies using representative tasks focus on perceptual-cognitive skills, predominantly focusing on anticipation across a variety of sports. The general procedure and methodology involve participants viewing sport-specific video on a screen and being instructed to anticipate the outcome of the final opponent action that occurs after occlusion of the footage (e.g., Weissensteiner, Abernethy, Farrow & Muller, 2008; Williams, Ward, Ward & Smeeton, 2008; North, Ward, Ericsson & Williams, 2011:

for a review, see Williams, Ford, Eccles, & Ward, 2011). Expert athletes demonstrate superior perceptual-cognitive skills and processes when compared to lesser-skilled players, including a greater ability at fixating upon key information in situations, anticipating situations, recognising situations, and selecting and executing decisions (for a review, see Williams et al., 2011). For example, an early study that has been replicated many times was conducted by Williams et al. (1994) in which they assessed these skills in soccer in their laboratory. They had participants anticipate ball direction using an 11 *vs.* 11 soccer film sequences presented on a large video projection screen that was occluded prior to a key action in play. The researchers found that experienced players were more successful at anticipating the forthcoming key action of an opponent in possession of the ball compared to inexperienced players. Inexperienced players fixated vision more frequently on the ball and the soccer players passing the ball, whereas experienced players fixated more on the positions and movements of opponents by using a visual search strategy involving more fixation locations of shorter duration. Therefore, a key difference between inexperienced and experienced soccer players was their ability to extensively search the display and pick-up useful visual information in advance to guide performance. Researchers who use laboratory-based representative tasks to examine the decision-making processes of expert players tend to assess *single* decisions in a situation on each trial. There exists no quantitative analysis to determine how frequent or what type of action executions are involved during actual soccer match play.

Decision making during sport performance. Decision making has been cited as having a key role in sport performance, particularly at higher levels of the sport (Williams et al., 2011). However, to date, no research has been conducted that aims to quantify the decision-making demands on soccer players during match-play. In

contrast, considerable research has been conducted quantifying the physical (e.g., Andrzejeski, Chmura, Pluta, & Kasprzak, 2012) and technical demands (e.g., Carling, 2010) of soccer players during training and match play. For example, the physical demands of soccer players during match-play have been examined using several methods, including hand notation, performance analysis and tracking software (e.g., GPS sports tracking). Researchers have shown that during match-play soccer players cover an average of 9-13 kilometers per 90-minute game (Hoff, 2005), engage in an activity every 4-6 seconds (Bangsbo, Norregaard, & Thorso, 1991), make approximately 1,000-1,500 discrete movement changes, 30-sprints, 700 turns (Bloomfield, Polman, Butterly & O'Donoghue, 2005), spend 53 seconds per match in possession of the ball, and complete on average 47 individual possessions (Carling, 2010). Given that these physical and technical actions are the product of the selection and execution of decisions by players, it is likely the decision-making load of athletes in team sports is similarly demanding.

One of the difficulties in conducting research assessing decision making demands during sport performance is that it involves the processes of action planning, programming and selection that are not directly observable (e.g., Stelmach, 1982). However, *action executions* in decision-making and the effects of those actions in the environment are directly observable, and they have been measured in some sports, such as basketball and tennis. French and Thomas (1987) examined the relationship between sport knowledge, decision making and sport skill in actual game performance. The cognitive and motor skill components of basketball game performance in skilled and novice child players were coded using a direct observational instrument. Skilled players made a higher percentage of correct decision selections when in possession of the ball (85% in Study 1 and 88% in Study 2) compared to novice players (51% in

Study 1 and 58% in Study 2). However, the success of action executions discriminated groups to a lesser extent, with skilled players making a higher percentage of successful action executions with the ball (76% in both studies) compared to novices (63% in Study 1 and 62% in Study 2). The 75% success rate for action executions on the ball in match-play appears across studies in experts and could be an indicator and baseline of successful performance (for similar, see McPherson and Thomas, 1989). This research indicates that the expertise and level of knowledge for sport situations possessed by players affects the quality of decision made within the game.

McPherson and Thomas (1989) examined the development of knowledge structures and game performance in skilled and less-skilled male youth tennis players. The players were compared on tennis performance (decision selection and execution success) in game play and tennis knowledge. To investigate tennis game play performance, players were video recorded during actual game play. Using a developed observational coding system, the serve and subsequent strokes during tennis game play were coded for decision selection and execution quality and success. To examine how tennis knowledge facilitated tennis decision-making ability during game play the researchers recorded verbal reports. Two types of interviews were used: a situation interview to assess the current status of tennis knowledge and a point interview to assess how this knowledge was employed during game play. Skilled players selected a higher percentage of correct decisions when serving (89% of serves) and playing strokes (84% of strokes) compared to their less-skilled counterparts (41% of serves and strokes). Moreover, the skilled players executed a higher percentage of quality serves (51%) and strokes (52%) when compared to the lesser-skilled players (15% of serves and 25% of strokes). For the interviews the researchers found that skilled players, when compared to novices, focused on higher level match concepts, had more

connections between concepts and had more condition and alternative action concepts that were important to the game goal structure. These two research studies (French & Thomas, 1987; McPherson & Thomas, 1989) show that action planning/selection is not directly observable, however, action selection/execution is directly observable.

A few other researchers have assessed the success of actions executed. Redwood-Brown, O'Donoghue, Nevill, Saward and Sunderland (2019) investigated the effects of playing position, pitch location, team ability and opposition ability on technical performance variables (pass, cross, corner, free-kick accuracy) of English Premier League (EPL) soccer players. A total of 570 players across 376 games were analysed. The researchers found that the average passing accuracy per player per game was 73.6 per game (*SD* = 5.5%). With regards to corners, crosses and free-kicks the success of players was 19.7 (*SD* = 2.6%), 45.4 (*SD* = 8.3%) and 63.9 (*SD* = 12.1%), respectively. Across two studies (Redwood-Brown et al., 2019; French & Thomas, 1987), a success rate of actions executed by skilled players during gameplay has been 70-75%, suggesting this value may reflect skilled performance during gameplay.

Identify the underlying mechanisms that mediate expert performances

In the second phase of the Expert Performance Approach the aim is to determine the underlying mechanisms that facilitate expert performance. There are a few examples of techniques that may be employed during this stage to identify mediating processes, including eye-movement recording, film occlusions and verbal report protocol analysis (Williams, Hodges, North, & Barton, 2006). In team ball sports, such as soccer, many researchers have used eye-movement recording to examine the visual search behaviours employed by skilled and lesser skilled/experienced players (e.g., Salvesbergh, Williams, van der Kamp, & Ward,

2002; Vaeyens, Lenoir, Williams, Mazyn, & Philippaerts, 2007b). For instance, Vaeyens et al. (2007b) examined perceptual-cognitive skill using film-based simulations of offensive patterns of play in soccer. Participants were split into three groups: 21 elite, 21 sub-elite and 23 regional male adolescent players. The researchers assigned the players into successful and unsuccessful groups based on their performance on a laboratory-based test of tactical skill. Using soccer-specific film simulations, movement-based response measures, and eye movement registration techniques, the investigators determined the decision-making processes and skill level of the players. When compared to their less successful counterparts, successful decision-makers used more goal-orientated visual search strategies, which resulted in superior performance, found by faster decision times and greater response accuracy. Successful decision-makers spent more time fixating the player in possession of the ball and alternated gaze more frequently between the player and other display areas. In a similar manner, Roca, Ford, McRobert and Williams (2013) examined the perceptual-cognitive skills underlying anticipation and decision making in skilled and less skilled soccer defenders. Participants interacted with life-size film sequences of 11 *vs*. 11 soccer situations shown on a large screen in which the ball as located in the offensive or defensive half of the pitch (far *vs.* near conditions). Skilled defenders demonstrated more accurate anticipation and decision making when compared to lesser-skilled footballers, regardless of the condition, with their superior performance being underpinned by differences in visual search behaviours and cognitive thought processes. Skilled defenders employed quantitatively different visual search strategies when viewing far tasks compared to near tasks and compared to less-skilled players. In the far task, skilled soccer players used visual search patterns involving more fixations of shorter durations to more disparate and informative areas, whereas less-

skilled participants spent more time fixating on the ball and the player in possession. In near tasks, skilled defenders typically employed fewer fixations of longer durations mostly towards the player in possession of the ball when compared to the lesser-skilled players. Moreover, verbal reports of cognitions from skilled defenders contained more monitoring, predictive, planning and evaluative statements when compared to the lesser-skilled players. In general, the superior anticipation and decision making of expert soccer players are mediated by the quantitatively different underlying mechanisms of visual search and thought processes when compared to lesser-skilled players.

A related process that impacts on performance in soccer is visual exploratory actions that occur during match play (McGuckian, Cole, Jordet, Chalkley, & Pepping, 2018). Visual scanning movements can be expressed through left and right rotations of the head, which allows the perception of a surrounding environment and supports prospective actions. The extent to which this exploratory search benefits a subsequent performance with the ball is likely influenced by how and when the exploratory action occurs. McGuckian et al. (2018) conducted the first study in which the relationship between visual exploration through head turns and on-pitch football performance was examined. They investigated the relationship between head turns and performance in 32 semi-elite football players during 11*vs.*11 match-play. Head turn frequency and head turn excursion (the total radial distance of the head turn) before ball possession were quantified with wearable inertial measurement units, and actions with the ball were coded via notational analysis. A total of 783 actions with the ball were analysed. There was a strong relationship between head turn frequency and head turn excursion. Furthermore, a higher-than-average head turn frequency and head turn excursion before receiving the ball resulted in a higher likelihood of turning with the ball, playing

a pass in the attacking direction, and playing a pass to an area that is opposite to which it was received from. It appears frequent visual exploratory behaviour can have a positive effect on success in soccer performance.

Examining how the mediating mechanisms and expert performance are acquired

The third and final stage of the Expert Performance Approach seeks to assess and determine how experts acquire and develop the skills and mechanisms needed to demonstrate superior performance. This stage is essential as it is important to understand how experts acquire the skills needed to demonstrate superior performance. The main body of research within this area has tended to rely on deliberate practice theory (Ericsson et al., 1993). The main claim of the framework is that superior performance is gained through extensive periods of time spent in domain-specific deliberate practice, with the main aim of improving current levels of performance. Ericsson (2020; Ericsson et al., 1993) holds that deliberate practice in sport is led by coaches working one-to-one with an athlete and identifying a key aspect of performance to improve and validated methods by which to improve it, then subsequently engaging in effortful coach-led individual practice to improve it, involving individualised feedback from the coach and later evaluation. The deliberate practice theoretical framework has been used to examine and differentiate expert and less expert performers based on environmental factors and the types of practice activity that athletes are exposed to. One of the popular methods used to identify acquisition sources accounting for expertise in sport is the use of retrospective recall by athletes of their participation history via questionnaires, interviews, and time motion analysis (Cote, Ericsson, & Law 2005).

Researchers have used retrospective recall methods to test deliberate practice theory in sport. One of the first studies to assess the theory in sport was Helsen et al. (1998) across two studies. In Part I, international (mean age 25.6 years), national (mean age 24 years), and provincial (mean age 25.4 years) soccer and field hockey players recalled the amount of time they spent in individual and team practice, sport-related activities, and everyday activities at the start of their career and every three years since. In Part II, these activities, and everyday activities were rated in terms of their relevance for improving performance, effort and concentration required, and enjoyment. A monotonic relationship between accumulated individual plus team practice and skill level was found. In contrast with findings in Ericsson et al. (1993) for musicians who found deliberate practice not enjoyable, relevant activities for the team sport players were also enjoyable, while concentration became a separate dimension from physical effort. Subsequent studies (e.g., Ward et al., 2007) confirmed the finding that coach-led team practice in sport was enjoyable. Ericsson (2020) concluded that coach-led team practice cannot meet the criteria for individualized training selected by a coach for an individual athlete, hence why team practice does not share the characteristics of deliberate practice.

Retrospective recall methods have been used to assess the link between practice activities and perceptual-cognitive components of performance, such as anticipation skills (e.g. Ford, Low, McRobert, & Williams, 2010, Ford, Williams, Hodges, & Williams, 2009, Helsen, Starkes, & Hodges, 1998). For instance, Ford et al. (2010) examined the developmental activities that contributed to the development of superior anticipation skill among adolescent cricket batters. The cricket batters viewed 36 video clips involving deliveries from bowlers. The video was occluded at ball release and the cricket batters were required to predict delivery types. Accuracy

scores on the anticipation task were used to differentiate two subgroups : high-performing and low-performing anticipators. The researchers used questionnaires to record the participation history profiles of the participants. During the early stages of development in childhood, hours accumulated in cricket and other sports did not differentiate between groups. However, significant between-group differences in activity profiles were found between 13 and 15 years of age, with high-performing anticipators accumulating more hours in structured cricket activity, and specifically in match-like batting activity, when compared with their low-performing counterparts. It appears that the amount of activity that athletes engage in is important for perceptual-cognitive skill development, but also the types of activity that they participate in.

Types of practice structure. One of the main tasks for soccer coaches is to design and lead practice activities for their athletes. In soccer coaching, particularly youth soccer coaching, these practice activities should lead to relatively permanent skill acquisition in athletes that transfers to their improved performance during competition. Coaches of team sports have been shown to use two types of activities in their practice sessions that have differential effect on skill acquisition of their athletes (Ford, Yates, & Williams, 2010a; Low et al., 2013). Activities *without active decision making* (NDM) are those in which the coach pre-determines action selections for the athletes so that they are not actively making them when engaging in the practice, such as in drill-based technique activity. In contrast, activities with *active decision making* (ADM) are those in which players are actively making action selections during performance themselves based on the positioning of teammates, opponents, and space, such as in game-based activities. ADM coaching activity is predicted to lead to greater transfer of perceptual, cognitive and motor skills to competition activity compared to NDM activity (Ford, 2016). These skills include visual search and decision making,

which have consistently been shown to differentiate expert from lesser-skilled athletes in team sports (for reviews, see Ford & Williams, 2013; Williams et al., 2011). However, team sport coaches have been shown to use more NDM activity during practice sessions compared to ADM (Ford et al., 2010; Low et al., 2013). For example, 25 coaches of child and adolescent soccer teams from the elite, sub-elite and recreational level in England had their players engage in NDM activity for 65% of session time and ADM activity for 35% of session time across 70 analysed coaching sessions (Ford et al., 2010), with no differences between age and skill levels. The effect on the athlete of engaging predominantly in NDM activity during coaching sessions is that acquired skill may not transfer successfully to improved competition performance, particularly perceptual-cognitive skill. Multiple researchers have shown that expert athletes demonstrate superior perceptual-cognitive skills when compared to lesser-skilled athletes (Williams, Davids, Burwitz, & Williams., 1994; Williams et al., 2011; Roca et al., 2013), so coaching session practice, especially for youth athletes, should lead to this outcome.

Similarly, Low et al. (2013) investigated the coaching sessions of child and adolescent cricket players at recreational and elite level in England. Players spent 69% of session time in NDM activity and 19% in ADM, with the remaining percentage of time spent in transition between the two activities, again with very few differences across skill or age groups. The effect on the athlete of engaging predominantly in NDM activity during coaching sessions is that acquired skill may not transfer successfully to improved competition performance. In contrast, more recently, O'Connor, Larkin and Williams (2017) used systematic observation tools to explore the sequencing of football coaching sessions in Australia. A total of 66 coaching sessions were recorded from 34 youth soccer coaches (n = 19; U11-U13 and n = 15; U14-U17) using an

adapted version of the Ford et al. (2010) soccer practice activity coding system. In contrast to previous findings, the coaches had their players engage in 40.9% (*SD* = 14.8) ADM, 22.3% (*SD* = 13.4) NDM, 31% (*SD* = 9.8) inactivity, and transitions between activities was 5.8% (*SD* = 4.3). It appears that modern coach education might have influenced coaches to schedule greater amounts of ADM activity.

Aims of the thesis

There is a need to assess the action execution load in soccer match-play and to evaluate modern coaching practice and coach education for the extent to which they promote player decision-making and its importance to superior match-play performance. The aim of this thesis is to assess and analyse the action execution load of professional soccer players during match-play and training and how coaches seek to develop these abilities. The aim of Chapter 2 (Study 1) is to quantify and analyse the frequency, type and success of decisions executed as actions in professional soccer players during professional soccer matches in the English Premier League (EPL), as well as investigating the effect of positional role, time and phase of play. Fifteen professional soccer players representing three home teams during the 2013-2014 season in the EPL (n = 5 players per team) were analysed across three matches per team, totalling 45 observations. Soccer players from each team were equally divided into five positions: centre-back (n = 3), full-back (n = 3), wide-midfield (n = 3), centre-midfield (n = 3) and centre-forward (n = 3). Video footage was analysed for the total frequency and type of every player action execution during the match. Bloomfield et al (2007) revealed that soccer players execute 1,000 to 1,500 movement changes during a 90-minute soccer game. Based on this research it was hypothesised that soccer players would execute 1,500 action executions or more in a 90-minute soccer game. It

was expected that centre-midfield players would execute the most actions per match, whereas full-backs would execute the least amount of actions per match (Andrzejewski et al., 2012). Players were expected to execute more actions in the first compared to the second half (Reilly & Thomas, 1976).

The aim of Chapter 3 (Study 2) was to examine the types of practice activities that coaches have youth soccer players engage in England to assess their opportunities for decision making of the type measured in Chapter 2 (Study 1). Thirty-six soccer coaches and their youth teams took part in this study. There were two child and two adolescent teams from each of the three Category 1 English Football Association (FA) Youth Soccer Academies (YSA); three Category 3 FA YSA; and three local recreational football clubs. Three sessions per team were filmed and footage was analysed for the percentage of session's time spent in ADM, NDM and transition, as well as measures of practice specificity, including turf used, directional orientation, and size of the activity area. It was expected that the amount of ADM has increased and would be greater than NDM activities when compared to that found previously (e.g., Ford et al., 2010).

The aim of Chapter 4 (Study 3) is to examine the effectiveness of a Football Association (FA) coaching course in changing coach behaviour related to designing practice so as to increase player decision making during that activity and, subsequently, player skill acquisition and transfer to match-play. Three coaches who took part in the coaching course and their U11 elite players participated. They were filmed for three coaching sessions prior to and three sessions after the course. The video of the sessions was analysed for the proportion of time spent in ADM, NDM and transition between the two activities. Moreover, after each of the three coaching sessions before and after the course, the players took part in an 8 *vs*. 8 small-sided

game that was filmed. Analysis of course content and semi-structured interviews with the coach educators were conducted. We expect the coaching course to advocate and, subsequently, lead to an increased amount of ADM activity in practice sessions occurring after the course compared to before it, with an associated increased amount of visual scanning and better decision making by players during small-sided games after the course and sessions compared to before them.

Chapter 2

Study 1

Abstract

Expert team sport players are superior at selecting and executing decisions during representative tasks when compared to lesser-skilled players. However, there is a lack of research quantifying the action executions load of team sport players during match play. The aim of this study was to examine the frequency and type of actions executed by professional soccer players during soccer matches. Professional soccer players (n = 15) representing three successful teams in the English Premier League (EPL) participated. Player positions were centre backs (n=3), full backs (n=3), wide midfielders (n=3), centre midfielders (n=3) and strikers (n=3). Wide-angled video footage of the full pitch during three home matches per player was recorded and analysed. The frequency of every action executed during the 90-min matches was analysed as a function of phase of play, half and positional role. Soccer players executed 2,103 (SD = 149) actions per match, averaging 21.8 (SD = 1.5) actions per minute. They had 60 (SD = 20) ball possessions per match, of which 75% were successfully executed. More actions were executed in the first half (22.3 actions per minute (SD = 1.7)) compared to the second half (21.1 actions per minute (SD = 1.9)). More actions were executed when in possession of the ball (89.9 actions per min, (SD = 121.8)) and fewer actions were executed when the ball was out of play (11.1 actions per min, (SD = 2)) compared to other phases of play. Positional role did not affect the frequencies of actions executed and ball possessions. However, the number of ball touches was greater for wide-midfielders (158 touches, (SD = 49)) when compared to centre-backs (88 touches, (SD = 36)), with no differences in ball touches between all other playing positions. Players in the EPL executed over 2,000 different actions across a match, demonstrating the key role of decision-making during expert soccer match-play performance. Findings indicate that the training and preparation of players

should incorporate decision-making activities that specifically replicate match play to enable them to perform successfully in future.

Introduction

Soccer performance requires players to select and execute fast and accurate decisions during performance. Researchers have mainly assessed decision-making in sport and its underlying mechanisms in laboratory- and video-based representative tasks (for a review, see Williams, Ford, Eccles & Ward, 2011). To date, no research has been conducted that seeks to quantify the decision-making demands on players during match play activities. In contrast, the physiological (e.g., Andrzejeski, Chmura, Pluta & Kasprzak, 2012; Cunniffe, Proctor, Baker & Davies, 2009) and technical demands (e.g., Carling, 2010) of players during match play are well documented. One of the difficulties in conducting research assessing decision-making demands in sport environments is that it likely involves the perceptual-cognitive processes of recognition, action selection and action planning that are not directly observable (e.g., Stelmach, 1982; McGuckian, Cole, Jordet, Chalkley & Pepping, 2018). However, action executions in decision making and the effects or success of those actions in the environment are directly observable. The aim of this study is to quantify the frequency and type of action executions in professional soccer players during matches in the English Premier League (EPL) as a function of positional role, time and phase of play.

Researchers have typically used laboratory- and video-based representative tasks to examine decision-making processes in expert athletes. They have shown that expert ball sport players demonstrate superior perceptual-cognitive processes when compared to lesser-skilled players, including a greater ability to fixate vision upon key information, recognise situations, anticipate situations, and select and execute decisions (Williams et al., 2011). For example, the perceptual-cognitive skills underlying anticipation and decision-making judgments in skilled and less-skilled soccer defenders were examined by Roca, Ford, McRobert and Williams (2013).

Participants interacted with life-sized film sequences shown on a large screen of 11 *vs*. 11 soccer situations filmed from the perspective of the defender in which the ball was located in the offensive or defensive half of the pitch (far *vs*. near conditions). The film occluded at foot-ball contact by an opponent at a key moment in the situations. Participants were required to move in response to the situations and to verbally respond with their anticipation and decision-making action execution judgments immediately afterwards. Skilled defenders demonstrated more accurate anticipation and decision-making judgments in comparison to those chosen by qualified coaches and when compared with the lesser-skilled players, regardless of the condition. Their superior performance was underpinned by differences in visual search behaviours and cognitive thought processes. During the far task, skilled soccer players used visual search patterns involving more fixations of shorter durations to more disparate and informative areas (teammates, opposition and areas of free space, player in possession of the football), whereas less-skilled players spent more time fixating on the ball and the player in possession. During near tasks, skilled defenders employed fewer fixations of longer duration mostly towards the player in possession of the ball when compared to the lesser-skilled players. Moreover, verbal reports of cognitions by skilled defenders contained more monitoring, predictive, planning and evaluative statements when compared to the lesser-skilled players. However, the representative tasks typically used to examine the decision-making processes of expert players tend to assess *single* decisions in a situation on each trial, but they do not demonstrate how frequent these decisions are in match play or how they differ from one another.

Decision making is thought to be central to sports performance, particularly at higher levels of the sport (Williams et al., 2011). However, there is a lack of research examining the decision-making demands of expert athletes during competition and

training. In contrast, considerable research has been conducted quantifying the physical (e.g., Andrzejeski et al., 2012) and technical demands (e.g., Carling, 2010) of athletes during training and competition. For example, the physical demands of soccer players during match play have been examined using a few methods, including hand notation, performance analysis and tracking software (e.g., GPS sports tracking) (Cummins, Orr, O'Connor, & West 2013). Researchers have shown that during match-play, soccer players cover an average of 9-13 kilometres per 90-minute game (Hoff, 2005) and engage in an activity every 4-6 seconds (Bangsbo, 1991). They make approximately 1,000 to 1,500 discrete movement changes, 30-sprints, 700 turns, spend 53 seconds per match in possession of the ball, and complete on average 47 individual possessions (Bloomfield, Polman, Butterly & O'Donoghue, 2007; Carling, 2010). Given that these physical and technical actions are the product of the selection and execution of decisions by players, it is likely the decision-making load of athletes in team sports is similarly demanding.

The physical and technical demands of soccer players differ between playing position and as a function of phase of play within the match (Di Salvo & Pigozzi, 1998; Reilly & Thomas, 1976; Rienzi, Drust, Reilly, Carter & Martin, 2000; Andrzejewski et al 2012), so it may be expected that decision making demands differ similarly. The effect of position on physical demands was assessed by Andrzejewski et al. (2012) across four professional soccer matches in the Union of European Football Association (UEFA) Cup. Midfielders (11,770 m (*SD* = 554)) travelled 3% further than attacking players (11,337 m (*SD* = 584)) and 7% further than defenders (10,932 m (*SD* = 728)). Elsewhere, strikers in 55 English Premier League matches spent more time when out of possession of the ball performing high intensity activities (27.3 s (*SD* = 12.4)) and in purposeful movements (5.5 s (*SD* = 3.3)) when compared with midfielders (14.2 s

(*SD* = 9.8); 6.4 s (*SD* = 3.1)) and defenders (2.5 s (*SD* = 1.3)) (Bloomfield, Polman & O'Donoghue, 2007). Additionally, the effect of phase of play on physical demands was assessed by Jozak, Peric, Bradic & Dizdar (2011) across the Fédération Internationale de Football Association (FIFA) 2010 World Cup Finals. Defensive midfielders (4.2km) and forwards (4.0km) covered the greatest distance when their team was in possession of the ball, whereas defensive midfielders covered the greatest distance (4.4km) when their team was not in possession of the ball. Moreover, centre-backs made the most actions per minute when they were in possession of the ball and wide-midfielders executed the least. Furthermore, Carling (2010) analysed the physical demands when running with the ball in professional soccer across 30 French Ligue 1 matches across two seasons. Differences existed in the total distance covered in possession at various movement speeds and these differences were dependent on playing position. Additionally, the researchers found that the mean distance, duration and speed of possessions, number of touches taken and distance from nearest opponent when receiving the ball also varied across playing positions. Finally, the total distance did not differ between halves but varied over the course of matches, decreasing just before half-time. As the physical and technical demands of team sports is affected by positional role and the phase of play within the game, then it is expected that similar differences may exist in decision-making demands (e.g., Williams, Ward, Ward & Smeeton, 2008; see also Bruce, Farrow, & Raynor, 2012).

Athletes in team sports become fatigued during competition, especially in the latter stages of the event, which is hypothesised to negatively affect decision making. For example, total distance covered by professional soccer players (Reilly & Thomas, 1976) and the amount of high intensity activity (Reilly, Drust & Clarke, 2008) is lower in the second compared to the first half of matches. Additionally, Burgess et al. (2006)

reviewed the work rate profiles of Australian League soccer players and found that distance covered significantly decreased during the second half of matches. However, Di Salvo et al. (2007) showed no significant differences in work rates between halves for elite Spanish and European soccer players participating in the La Liga and UEFA Champions League games. Other researchers have assessed the effects of "fatigue" on decision-making in sports under laboratory conditions. Casanova, Garganta, Silva, Alves, Oliveira and Williams (2013) measured the effects of prolonged intermittent exercise on perceptual-cognitive processes. They measured the visual search behaviours and thought processes underpinning anticipation judgements and how these are influenced by intermittent exercise in 8 high- and 8 lower-skilled soccer players. Players completed a soccer-specific, intermittent exercise protocol that simulated the physical demands of a 90-minute match while responding to filmed sequences of offensive play. High-level players demonstrated superior anticipation compared with low-level players, but both groups showed a reduction in accuracy across the exercise protocol. Another study to investigate the effect of fatigue on perceptual-cognitive skills was conducted by Vickers and Williams (2007). They examined the effects of fatigue onset on quiet eye period and shooting performance in Canadian biathletes during blocks of 10 shots towards a concentric circle target under varying levels of physiological stress. Quiet eye is defined as the final fixation on the target prior to the initiation of movement (Vickers, 2009). The duration of quiet eye and shooting performance decreased with the onset of fatigue. Findings suggest that physiological fatigue in elite athletes has a negative effect on visual search behaviour, which ultimately may hinder the decision-making process.

Decision-making in sports is likely the result of processes within the brain integrated with sensory information from the environment (Williams & Ford, 2013).

The processes of recognition, action selection, and action planning are not externally observable (e.g., Stelmach, 1982), whereas action execution and the effects or success of those actions in the environment are externally observable. During the 20th Century, the internalised processes of recognition, action selection, and action planning were often measured with reaction time methodologies in which a stimulus is presented (e.g., on a computer screen) and participants must execute a simple movement response (for reviews, see Stelmach, 1982; Luce, 1986). Reaction time is defined as the time period from when the stimulus is first presented to when the movement response starts. Greater complexity or difficulty of stimulus or response increases reaction time, suggesting the internalised processes of recognition, selection and/or programming are taking longer (e.g., Hick's Law, Hicks, 1952; Fitt's Law, Fitts & Peterson, 1964). In the 21st Century, these internalised processes associated with stimulus and responses are being measured at a neurophysiological level (for a review, see Cisek & Kalaska, 2010). However, these methodologies do not currently permit measurement of recognition, action selection, and action planning to be made during complex perceptual-cognitive-motor tasks, such as the match play activities found in games-based sports.

A series of behavioural studies by Thomas, McPherson and colleagues (French & Thomas, 1987; McPherson & Thomas, 1989; McPherson & French, 1991; McPherson, 1999; McPherson & Kernodie 2007) have demonstrated that *action executions* during sport game performance *are* observable externally and can be differentiated by the success of those action executions. For example, the appropriateness of decisions executed as actions and their success were analysed in 17 skilled and 17 novice child basketball players during game play using a hand notation coding instrument (French & Thomas, 1987). During game play, skilled players

selected appropriate decisions and executed successful actions more frequently compared to novice players. In addition, appropriate decisions were selected more frequently compared to the success of those actions, with skilled players choosing appropriate decisions for 85% of presented opportunities and 76% of actions being successful, whereas novices demonstrated a ratio of 51% to 63%, respectively. Although these studies show the decision-making processes of action execution and the success of those actions are observable, they do not provide information on the quantity or load of decision-making in game-based sports across a full game. Similarly, Redwood-Brown, O'Donoghue, Nevill, Saward and Sunderland (2019) investigated the effects of playing position, pitch location, team ability and opposition ability on technical performance variables (pass, cross, corner, free-kick accuracy) in English Premier League soccer players. A total of 570 players across 376 games were analysed. The researchers found that the average passing accuracy per player per game was 73.6 (*SD* = 5.5%). With regards to corners, crosses and free-kicks players performed with on average 19.7 (*SD* = 2.6%), 45.4 (*SD* = 8.3%) and 63.9 (*SD* = 12.1%) accuracy respectively.

The decisions and action executions across match-play likely involve differing loads or challenges. Researchers are yet to examine and analyse the demand in load of each decision or action executed. For example, variation between the demand of a pass in the first half compared to a pass in the second half, or how the relative proximity of an opposition player influences the load demand. Realistically, it is very difficult to measure the different loads of each action and the capacity of the outcome. Cognitive Load Theory (CLT) relates to the amount of information that working memory can hold at one time (Sweller, 1988). As working memory has a limited capacity, it may be that decisions and action executions with a high cognitive load exceed the amount

of information that working memory can hold and are those that are less successful. Alternatively, the Challenge Point Hypothesis (Guadagnoli & Lee, 2004) suggests the functional task difficulty of high-load situations may exceed the existing capabilities of the player because there is too much information in the current situation, causing unsuccessful decisions or actions executions. However, this research seeks to examine the load of action executions as a proxy for decision making because the methods employed are unable to quantify the load of each action.

The aim of this study is to quantify and analyse the frequency, type and success of decisions executed as actions in professional soccer players during soccer matches in the EPL, as well as investigating the effect of positional role, time and phase of play. Fifteen professional soccer players representing three home teams during the 2013-2014 season in the EPL (n = 5 players per team) were analysed across three matches per team, totalling 45 observations. Soccer players from each team were equally divided into five positions: centre-back (n = 3), full-back (n = 3), wide-midfield (n = 3), centre-midfield (n = 3) and centre-forward (n = 3). Video footage was analysed for the total frequency and type of every player action execution during the match. Bloomfield et al. (2007) revealed that soccer players execute 1,000 to 1,500 movement changes during a 90-minute soccer game. Based on this research it was hypothesised that EPL soccer players would execute 1,500 action executions or more in a 90-minute soccer game. It was expected that centre-midfield players would execute the most actions per match, whereas full-backs would execute the least amount of actions per match (Andrzejewski et al., 2012). Players were expected to execute more actions in the first compared to the second half (Reilly & Thomas, 1976). Moreover, phase of play was predicted to affect the rate per minute (RPM) of action executions, such that it was expected to be greater for players in possession of the ball when compared to

other phases of play. Based on the findings of Jozak et al. (2011) for phases of play, it was predicted that midfielders would execute the most actions per minute when their team was in and out of possession of the ball compared to all other positions, perhaps with forwards being not different to midfielders when team was in possession. Moreover, centre-backs will execute the most actions when players are in possession of the ball. However, based on the findings of Carling (2010), it was hypothesised that full-backs, centre-midfielders and wide-midfielders would have substantially more ball possessions than centre-backs and centre-forwards. It was expected that wide-midfielders and full backs would have more touches on the ball when compared to other positions (Carling, 2010). Based on previous research (French & Thomas, 1987; Redwood-Brown et al., 2019) it was hypothesised that in possession success rate ball executions would be around 75%.

Methods

Participants

Fifteen professional soccer players representing three teams (n = 5 players per team) in the English Premier League (EPL) during the 2013-14 season participated. Participants mean age at the time of data collection was 28 years (SD = 4). They had an average of 223 appearances (SD = 171) for their current teams. The teams provided one player from each of five positions of centre-back (n = 3), full-back (n = 3), wide-midfield (n = 3), centre-midfield (n = 3), and centre-forward (n = 3). Each of the three teams finished the 2013-2014 season within the top seven places of the English Premier League. The research was conducted in accordance with the ethical guidelines of the lead institution. A gatekeeper provided informed consent from each team and they were free to withdraw from the study at any time.

Procedure

Video recording. Video footage of three EPL soccer matches was recorded from each of the three teams during the 2013-2014 season. The footage was filmed at the home stadiums of each team from a high-level gantry in the main stand of the stadium using a wide angled digital video camera (Canon, HF-M52, Japan) mounted on a tripod (Libec, Arizona, USA) positioned at around the halfway line of the pitch, as shown in Figure 2.0. All matches were played against other teams who finished in the top seven positions of the EPL that season. The home teams won 45% (5) of these matches; away teams won 27% (3) and 27% of the matches ended in a draw (3).

Figure 2.0. A still image of the wide angled video footage collected.

Video analysis. Video footage was analysed for the total frequency and type of actions executed by the players during the matches. Player actions executed were

either on the ball or off the ball and included *every* executed action made by each player during the match. Three sets of analysis were run on the video footage using performance analysis software (Sportscode Gamebreaker v. 8.5.2, Hudlsportscode, United Kingdom) containing a bespoke notation analysis instrument developed for this study. First, an analysis was run to separate the video footage into phases of play in the match using the definitions shown in Table 1.0.

Table 1.0. Definitions for phases of the match.

Phase	Definition
Team in possession	**Start**: Possession was deemed to have been gained when a player had sufficient control of the ball to affect a deliberate influence on its subsequent path. **End**: Possession was lost when the ball went out of play, an opposing player touched the ball or the referee blew the whistle for an infringement (James, Jones, & Mellalieu, 2004).
Team out of possession	**Start**: When the opposing team gains possession of the ball by any means other than from a player of their own team or when the ball goes out of play. **End**: When the player's team gains possession of the ball by any means other than from a player of the same team.
Player in possession	**Start:** When the player gains possession of the ball. **End:** When the player passes the ball to another teammate or loses the ball to an opposing player.
Out of play	**Start:** As soon as the ball crosses a touchline, the ball is classified out of play. Additionally, the ball is out of play when the referee blows the whistle to stop play for a foul, injury, cautioning players, substitutions.

End: As soon as the player taking the throw-in releases the ball from his hands or as soon as the players foot makes contact with the ball from a goal kick, free-kick, corner kick or penalty kick.

The four phases were player in possession of the ball, team in possession with player out of possession, team out of possession, and ball out of play. Second, the video footage was analysed for the frequency and type of every action executed by the players across the match using the definitions in Table 2.1 and 2.2. For example, the definition for a short pass was ‘an attempt by the player to play the ball to a teammate who is 15 yards or less away’. Each of the coding buttons on the software had a lead-time of 1 second and a lag-time of 0 seconds when pressed in order to record the frequency of action executions, as opposed to the length of time in which players engaged in an action. Third, the video footage was analysed for successful and unsuccessful ball possessions by the players using definitions in Table 3.0.

Table 2.1. The definitions used to analyse the actions executed by the players on the ball.

Action	Definition
Receive	When a ball is a passed, thrown, headed or rebounds to the player and he attempts to or does take control of the ball using a part of his body.
Control	Being in possession of the football but not dribbling or changing body direction.
Turn	Noticeable change of body direction whilst in possession of the football.
Dribble	Any run with possession of the football that involves either; a directional change and/or beating an opponent maintaining possession of the football while doing so.
Short Pass	Attempt by a player to play the ball to a teammate who is 15 yards or less away.
Long Pass	Attempt by a player to play the ball to a teammate who is 15 yards or more away.
Shot	Any attempt at goal when the player is in possession of the ball with any part of the body except the head.
Head	Any touch of the ball with a players' head except (header shot or headed pass).
Header Shot	Any attempt at goal when the player is in possession of the ball by using his head.

Headed Pass	Passing the ball successfully to a teammate with the head.
Clearance	A defensive touch undertaken by a player with no intended target and/or under pressure from the opposition (also applied to the scenarios when a player kicks the ball out of play to allow an injured player treatment or in a drop ball when possession is given back – often after an injury).
Cross	Any ball played from a player in possession of the ball into a wide area (including inside the penalty area) into the penalty area with the aim of creating a goal scoring opportunity.
Throw	Restart of play from a player's hands following a ball out of play.

Table 2.2. The actions and their definitions used to analyse the actions executed by the players off the ball.

Action	Definition
Stop	Standing stationary on one spot for 3 seconds or more when not in possession of the football.
Accelerate	A noticeable increase of pace from a stop, a walk, a jog, a cruise, a sprint or any other motion when not in possession of the football.
Decelerate	A noticeable decrease of pace from a sprint to, a cruise, a jog, a walk or a stop when not in possession of the football.
A walk	Moving slowly by stepping.
A jog	Moving at a slow monotonous pace (slower than running, quicker than walking).
A cruise	Manifest purpose and effort, usually when gaining distance.
A sprint	Maximal effort, rapid motion.
Change of Direction	Noticeably moving from one course to another with the same motion activity when not in possession of the ball or (when in possession of the ball and dribbling).

Accelerating and/or Decelerating with Change of Direction	Noticeably moving from one course to another with a different motion activity when not in possession of the ball or when dribbling.
Getting up from Ground	First movement to ascend from the ground when the player's full body is on the ground.
Standing Jump	Player jumping from ground from standing still but not when heading the football.
Moving Jump	Player jumps from ground when moving.
Tackle	Dispossession or attempted to disposes an opponent by physical challenge.
Block	Preventing the ball from reaching its intended target by a single touch. This can take place anywhere on the pitch. (i.e., if a shot is deflected and still scores then it is not counted as a block because it reached the intended target).
Contact	Make physical contact with another player (e.g., should barge, holding off).
Simulation	Players executing exaggerating body movements to fool the referee (e.g., dive).
Uncodable	Any events that takes place that could not be coded during the pilot study.

Table 3.0. Success of ball possessions.

Success of ball possessions	
Successful	When a ball is a passed, thrown, or headed to a team-mate and he attempts to or does take control of the ball using a part of his body. Also, any attempt at goal with any part of the body that is on target, where on target includes goals and saves within the posts by the opposition goalkeeper. In addition, dribbles that lead to the awarding of a free kick. Clearances, headers that are not shots or passes, and kicking the ball to the opposition goalkeeper to restart play or out of play for an injured player are all excluded.
Unsuccessful	When a ball is a kicked, controlled, dribbled, thrown, or headed, but is regained by the opposition or goes out of play or hits the goal frame. Clearances and headers that are not shots or passes are excluded.

Development and validation of the analysis instrument. The process outlined by Brewer and Jones (2002) was used to establish the validity of the notation analysis instruments and the reliability of the observer. The sequential stages prior to the analysis detailed above were: (i) the development and validation of the notation analysis instruments and their categories; (ii) observer training; and (iii) establishing the objectivity and reliability of the observer. Two experienced performance analysts and a coach within the research team created the analysis instruments or tools to examine the frequency and type of every action executed by the soccer players during the matches. The performance analysts and coach had an average of 7.7 (*SD* = 1.2) years of experience working in professional soccer.

Player action types and variations within each type were initially created from those used by Bloomfield et al. (2007) in their analysis of the physical actions executed by players during EPL matches in the 2003-2004 season. The content and face validity of the instrument used in our study was determined through a pilot study. It involved analysis of the frequency and type of every action executed by 8 players (2 centre-backs, 3 centre-midfielders, 3 centre-forwards) during five matches in the 2008 Union of European Football Associations (UEFA) Champions League. In this analysis, video footage was filmed from a high-level gantry in the main stand of the stadium using a wide angled digital video camera (Canon, HF-M52, Japan) mounted on a tripod (Libec, Arizona, USA). It was positioned at around the halfway line of the pitch and focused on the single player throughout the match. Match footage from the television coverage of the match was also used for reference.

During the pilot study, multiple evaluations and meetings occurred between the panel to determine the content and face validity of the instrument to ensure *every* individual action execution was accounted for across the wide variety in the sport.

Several actions executed by the players were identified during the pilot study analysis that were not accounted for in the initial version of the instrument and were subsequently added to it. The initial version of the instrument started with 24 coding categories, whereas this increased to 30 coding categories at the end of the pilot study in order to code *every* action execution. For example, the initial version of the instrument had separate categories for 'change of direction' and 'accelerating/decelerating'. However, the pilot study and panel identified that players 'accelerate/decelerate with a change of direction' simultaneously, so this category was added to the instrument. Table 2.1 and 2.2 show the actions and their definitions that resulted from this validation process and that were used in the study.

The resultant notation analysis instrument contained 13 potential on-the-ball actions and 17 potential off-the-ball actions (Table 2.1 and 2.2). It enabled the continuous sequence of every action executed by the player during the match to be recorded. For example, a player in one match when his team were out of possession of the ball may initiate and execute a jog run forward and then change direction and action to a slow sidestep across the pitch before receiving the ball. In this example, the player would have executed a frequency of three action executions (jog, sidestep, receive ball). Therefore, an action execution was defined as occurring during the match when the player executed a new action in the sequence that differed to the previous action.

During the pilot study it was decided that the match should be divided into phases of play (player in possession; team in possession but player out of possession; team out of possession; ball out of play) as the frequency and type of player actions were predicted to differ between these phases (Table 2.1 & Table 2.2). Moreover, the decision to measure the successful and unsuccessful ball possessions was taken (Table

3.0). Similar procedures were followed in order to develop content and face validity of the definitions in Table 2.1, 2.2 and 3.0.

To ensure logical validity and remove the individual bias of the research team, a panel of UEFA B qualified coaches (n = 2) and an experienced performance analyst (n = 1) reviewed the categories and definitions used in the coding instruments. The panel provided written feedback and agreed that the categories and definitions were appropriate for analysing action executions.

Observer training. A training program was implemented in order to determine the reliability and objectivity of the observer on the notation analysis instrument. Observer training procedures outlined in previous literature (Brewer & Jones, 2002; Darst et al., 1989) were used in this stage. The observer was required to learn the player actions and their definitions within the coding tool. The observer conducted several practice analyses of players in the EPL matches in order to successfully identify and record the player action executions using the definitions.

Inter- and intra-observer reliability. Quantitative analysis was conducted to determine the reliability and objectivity of the observer on the instrument. The lead observer and one of the experienced performance analysts used the instrument to conduct an analysis of five players in each of two EPL matches. An inter-observer agreement analysis was conducted between the two sets of observer analyses for these two matches. In addition, intra-observer reliability or re-test reliability was assessed across two matches that were analysed twice by the lead observer three weeks apart. Inter- and intra-observer agreement was calculated using the equation: (agreements / (agreements + disagreements)) x 100 (van der Mars, 1989). An agreement score of 85% or above provides quantitative evidence of suitable reliability and objectivity (van

der Mars, 1989). Both inter-observer (89%) and intra-observer (92%) exceeded this 85% threshold.

Following this process of establishing the validity of the notation analysis instrument and the reliability of the observer, the lead observer conducted the full analysis for each of the 15 players in each of the three matches for their team, making a total of 45 observations, taking 6 hours to complete one observation, so 270 hours in total.

Data analysis

Five data sets were extracted from the analysis: (i) the frequency of actions executed by each player during a 90 min soccer match; (ii) the frequency of actions executed by each player as a function of half; (iii) the frequency of actions executed by each player during each phase of play; (iv) the frequency of actions executed by each player according to phase of play as a function of positional role; and (v) success rate of ball possessions for each player. Means and standard deviations were used to descriptively report the total number of actions executed across the players. The mean duration of the soccer matches was calculated. Rate per minute (RPM) of actions executed was calculated by dividing the amount of time involved in a phase of play by the frequency of actions executed within that phase. RPM was calculated for each player position as a function of the four phases of play.

A paired *t*-test was conducted to compare the frequency of actions executed in the first compared to second half. Separate one-way ANOVAs were conducted to analyse: (i) frequency of actions executed between the five positions; (ii) rate per minute (RPM) of actions executed between the four phases of play; (iii) frequency of ball possessions between the five positions, (iv) frequency of touches on the ball between the five positions; and (v) frequency of successful ball possessions between

positions. The Bonferroni *post hoc* procedure was used for significant within-participant effects, whereas Tukey post hoc procedures were used for significant between-participant effects. Cohen's *d* and partial eta squared was used as a measure of effect size (.02 represents a small effect size, 0.5 a medium effect size and 0.8 a large effect size).

The alpha level for significance was set at $P < 0.05$ for all tests.

Results

Frequency of actions executed

The average duration of the soccer matches was 96.2 min (*SD* = 3.6). The players executed a mean of 2,103 (*SD* = 149) actions per match or a mean of 21.8 (*SD* = 1.5) actions per minute. They had a mean of 60 (*SD* = 20) ball possessions per match involving 217 (*SD* = 68) actions executed on the ball and 120 (*SD* = 49) touches of the ball per match. Table 4.0 shows the mean frequency of action executions as a function of playing positions. There was no significant difference between playing positions for frequency of actions executed, $F_{4, 40} = 2.07$, $P > 0.05$, $\eta^2 = 0.17$.

Table 4.0. Mean (SD) frequency and rate per minute (RPM) of actions executed by professional soccer players as a function of position and phase of play.

Phase	Centre-Back		Full-Back		Centre-Midfielders		Wide-Midfielders		Centre-Forward	
	Mean (*SD*)	RPM	Mean (*SD*)	RPM	Mean (*SD*)	RPM	Mean (*SD*)	RPM	Mean (*SD*)	RPM
Total	2,053 (166)	21 (2)	2,049 (197)	21 (1)	2,202 (90)	23 (1)	2,144 (94)	22 (1)	2,064 (133)	21 (2)
Player in possession	178 (62)	98 (69)	209 (53)	86 (25)	236 (78)	87 (22)	262 (69)	85 (11)	204 (50)	93 (9)
Team in possession	644 (110)	22 (6)	652 (85)	22 (5)	717 (79)	24 (5)	692 (73)	24 (5)	749 (107)	25 (6)
Team out of possession	842 (124)	29 (6)	804 (143)	28 (6)	860 (117)	30 (5)	783 (86)	27 (4)	722 (64)	25 (4)
Ball out of play	389 (80)	11 (4)	384 (79)	11 (3)	389 (56)	11 (2)	407 (35)	12 (3)	389 (38)	11 (3)

First *vs*. second half actions

The average duration of the first half was 47.5 minutes (*SD* = 1.4), whereas the average duration of the second half was 49.8 minutes (*SD* = 1.0). There was no significant difference between the number of actions executed in the first compared to second half, $t_{44} = 1.50$, $P > 0.05$, $d = 0.22$. However, there was a significant difference between the RPM of actions executed in the first compared to second half, $t_{44} = 3.75$, $P < 0.05$. The rate per minute of actions executed was greater in the first half (22.3 actions per minute (*SD* = 1.7)) compared to the second half (21.2 actions per minute (*SD* = 1.9)). The 95% CI for the mean of the differences was from 0.5 to 1.8 RPM.

Phase of play actions

Table 5.0 shows the duration of matches and phases (team in possession, team out of possession, player in possession, ball out of play). The duration of the phases of play varied, so RPM data is presented in this section. There was a significant difference between phase of play for RPM of actions executed, $F_{1.13, 15.80} = 148.83$, $P < 0.00$, $\eta^2 = 0.98$. *Post hoc* tests showed RPM was significantly greater for the phases of team in possession (23.6 RPM, (*SD* = 3.4)), team out of possession (27.8 RPM, (*SD* = 3.1)) and player in possession (89.9 RPM, (*SD* = 21.8)) when compared to the ball out of play phase (11.1 RPM, (*SD* = 2)) (95% CI of the mean difference = -16.0 to -8.9, $d = 4.5$; -19.5 to -13.8, $d = 6.4$; -95.3 to -62.2, $d = 5.1$, respectively). RPM was significantly greater for the player in possession phase when compared to team in possession (95% CI of the mean difference = -84.2 to -48.4 RPM, $d = 4.1$) and team out of possession (95% CI of the mean difference = -79.5 to -44.7, $d = 4$). There was no significant difference between RPM of actions executed for team in possession and team out of possession (95% CI of mean difference - -0.6 to 9 RPM, $d = -1.3$).

Table 5.0. Mean (*SD*) duration of phases (team in possession, team out of possession, player in possession & ball out of play).

Phase	Minutes
Player in possession	2.7 (1)
Team in possession	30.8 (5)
Team out of possession	29.2 (3.4)
Ball out of play	36.2 (4.9)
Total duration	96.2 (3.6)

Phase of play and position. Table 4.0 shows the rate per minute (RPM) of actions executed by players in different positional groups within the phases of play. When players were in possession of the ball, players across the five positions executed means of 85 to 98 actions per minute, with centre-backs executing the most actions per minute and wide-midfielders executing the least number of actions. When the team was in possession of the ball but not the player, the five positions executed means of 22 to 25 actions per minute, with centre-forwards executing the most actions (25) and full-backs executing the least number of actions (22). When the team was out of possession, players across the five positions executed means of 25 to 30 actions per minute, with centre-midfielders executing the most and centre-forwards executing the least. When the ball was out of play, all players executed 11 actions per minute apart from wide-midfielders who executed 12 actions per minute.

Ball possessions

Figure 3.0 shows mean (SD) frequency of ball possessions, touches on ball and success rates of ball possessions as a function of playing position. There was no significant difference between playing positions for frequency of ball possessions, $F_{4, 40} = 2.00$, $P > 0.05$, $\eta^2 = 0.16$. There was a mean of 60 ($SD = 20$) ball possessions per match. There was a significant difference between playing positions for number of ball touches, $F_{4, 40} = 3.14$, $P < 0.05$, $\eta^2 = 0.23$. *Post hoc* tests showed the number of touches for centre-backs (88 touches ($SD = 36$)) was significantly lower compared to wide-midfielders (158 touches ($SD = 49$)) (95% CI of the mean difference = 10 to 130 touches). There was no significant difference between other playing positions, with the mean number of touches on the ball being 120 ($SD = 49$) per match.

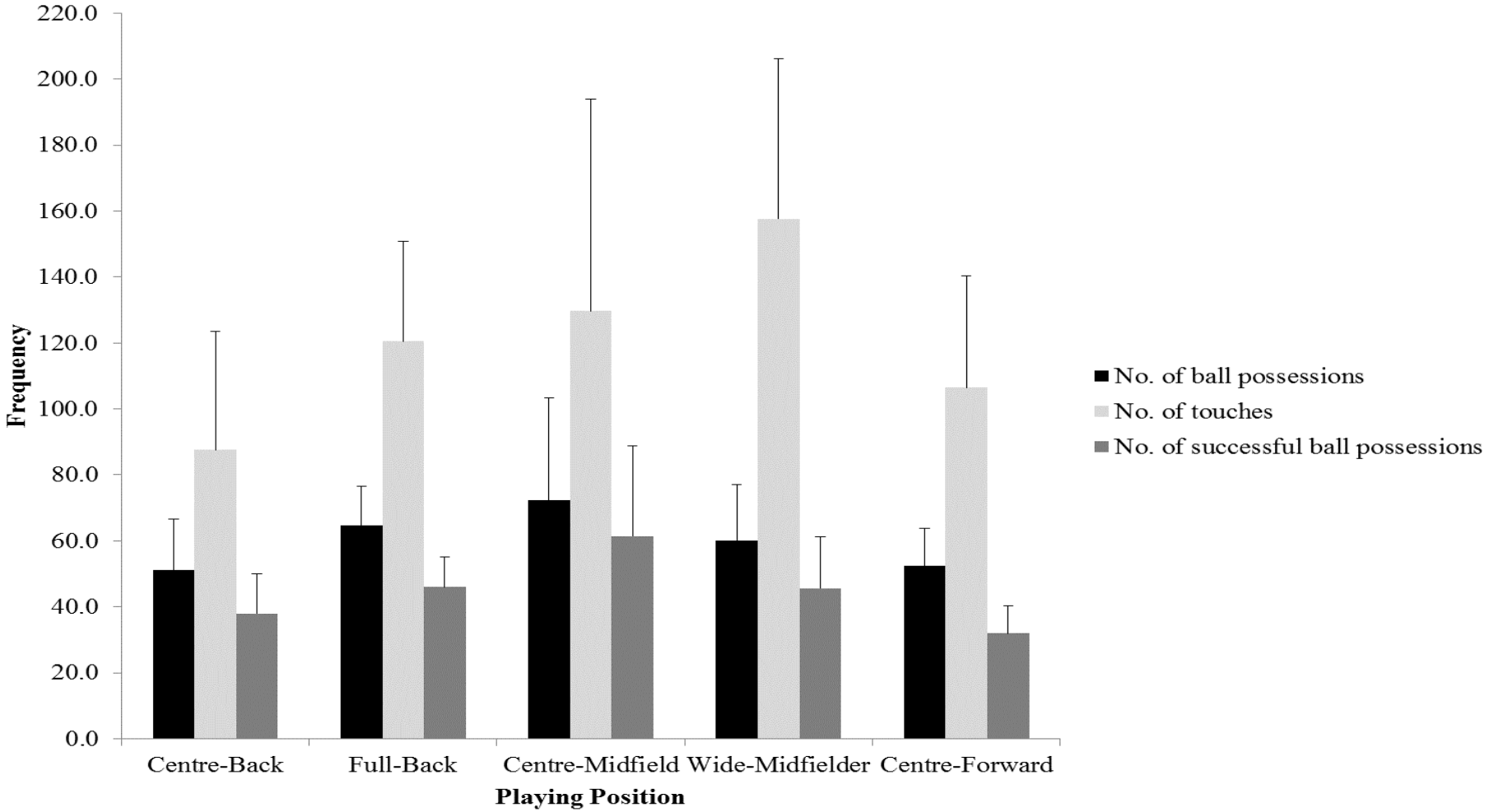

Figure 3.0. Mean (SD) frequency of ball possessions, touches on ball and number of successful touches as a function of playing position.

Success rates. The players had a mean of 60 (*SD* = 20) ball possessions per match, of which 45 (*SD* = 18) or 75% of ball possessions were successful and 11 (*SD* = 7) or 18% were unsuccessful, with 4 (*SD* = 4) or 7% of ball possessions uncoded. There was a significant difference between playing positions for the number of successful ball possessions, $F_{4, 40} = 4.27$, $P < 0.05$, $\eta^2 = 0.29$. *Post hoc* tests showed successful ball possessions for centre-midfielders (61.4 successful ball possessions (*SD* = 9.1)) were significantly greater compared to centre-backs (37.9 successful ball possessions (*SD* = 4.1)) (95% CI of the mean difference = 1.8 to 45.2) and centre-forwards (31.9 successful ball possessions (*SD* = 2.8)) (95% CI of the mean difference = 7.8 to 51.2). There were no significant differences between other playing positions.

Discussion

The aim of this study is to quantify and analyse the frequency and type of action executions in professional soccer players during match play in the EPL, as well as investigating the effect of positional role, time and phase of play. Soccer players executed 2,103 (*SD* = 149) actions per match, averaging 21.8 (*SD* = 1.5) actions per minute. They had 60 (*SD* = 20) ball possessions per match, of which 75% were successfully executed. More actions were executed in the first half (22.3 actions per minute (*SD* = 1.7)) compared to the second half (21.1 actions per minute (*SD* = 1.9)). More actions were executed when in possession of the ball (89.9 actions per min, (*SD* = 21.8)) and fewer actions were executed when the ball was out of play (11.1 actions per min, (*SD* = 2)) compared to other phases of play. Positional role did not affect the frequencies of actions executed and ball possessions. However, the number of ball touches was greater for wide-midfielders (158 touches, (*SD* = 49)) when compared to centre-backs (88 touches, (*SD* = 36)), with no differences in ball touches between all

other playing positions. There were also differences as a function of position for successful ball possessions too, with centre-midfielders having greater success in possession of the ball (61.4 successful ball possessions), compared to centre-backs (37.9 successful ball possessions) and centre-forwards (31.9 successful ball possessions).

Based on previous research (Bloomfield et al., 2007), it was expected that soccer players would execute more than 1,500 action executions in a 90-minute soccer game. Findings from this research project support and exceed this prediction as soccer players from the English Premier League executed a mean of 2,103 action executions per match, with differences between the two studies likely due to the more comprehensive analyses categories in the current study. Additionally, the demands of EPL matches have increased considerably since the Bloomfield et al. (2007) data was collected in 2006.

It was hypothesised based on previous research (Reilly & Thomas, 1976; Reilly et al., 2008; Burgess et al., 2006) that soccer players would execute more actions in the first compared to the second half. As predicted, there were significantly more actions per minute executed by the players in the first compared to second half. The vast majority of research comparing first and second half work rate activity profiles shows that players begin to "fatigue" during the second half of soccer matches (Burgess, Naughton, & Norton, 2006; Barros et al., 2007), supporting this finding of fewer actions executed per minute in the second compared to first half. It could be suggested that, as a result of soccer players covering less distances in the second half (e.g., Barros et al., 2007), they execute fewer actions. However, Di Salvo et al. (2007) showed no differences in work rate between halves, contradicting these findings. A possible explanation for differences in findings between research studies could be

differences in the physical demands and levels of play between leagues. Finding fewer actions executed per minute in the second compared to first half provides support for research showing "fatigue" hinders decision-making processes (e.g., Vickers & Williams, 2007). Although, the quality of all the actions executed were not directly measured, the findings from this study show a significant but small decrease in the rate per minute of actions executed in the second half compared to the first half, which could be attributed to physiological fatigue in the former compared to latter.

It was expected that centre-midfield players would execute the most actions per match, whereas full-backs would execute the least number of actions per match (Andrzejewski et al., 2012; Bloomfield et al., 2007). Much of the research suggests that centre-midfield players engage in more activity and cover more distance than any other position during matches (Andrzejewski et al., 2012; Reilly & Thomas, 1976; Rienzi et al., 2000). However, no significant differences between playing positions for the frequency of actions executed were shown in this study, although descriptive statistics showed centre-midfield players executed the most actions when compared to the other playing position analysed. A possible reason for the lack of position-based differences could be a due to all players constantly moving across the entire match, leading to no difference in total frequency of action executions between positions.

Based on previous work by multiple researchers (Jozak et al., 2011; Bloomfield et al., 2011; Andrzejewski et al., 2012), it was hypothesised that phase of play would affect the decision-making load, with the rate per minute of action executions expected to be greater for players when in possession of the ball compared to other phases of play. RPM of actions were significantly greater for the player in possession phase compared to all other phases, supporting that previous research. It was further predicted that midfielders would execute the most actions per minute when their team

was in and out of possession of the ball compared to all other positions, except for forwards when team was in possession. In support of this hypothesis and the findings of Jozak et al. (2011), centre-midfielders executed the most actions when the team was out of possession and when the team were in possession it was forwards and centre-midfielders who executed the most per minute. When players were in possession of the ball, centre-backs executed the most actions per minute and wide-midfielders the least. Finding supports that of Jozak et al. (2011) who also found that when players were in possession of the ball, centre-backs made the most actions per minute and wide-midfielders executed the least. We can appreciate from this data that the physical, technical and decision-making load changes across position and phase of play. Additionally, despite a lack of research examining the activity of soccer players while the ball is out of play, it can be suggested based on this current research that, rather obviously, soccer players make significantly less actions in this phase.

Based on the findings of Carling (2010), it was hypothesised that full-backs, centre-midfielders and wide-midfielders would have substantially more ball possessions than centre-backs and centre-forwards. The results from this study indicated that there was no significant difference between playing position and the frequency of ball possessions, however, centre-backs and centre-forwards had the least amount of ball possessions according to descriptive statistics, supporting the findings of Carling (2010). The lack of statistical difference between positions may be due to a few different factors including, team tactics, current game status and quality of the opposition (Fernandez-Navarro, Fradua, Zubillaga, Ford, & McRobert, 2016; Fernandez-Navarro, Fradua, Zubillaga, & McRobert, 2018; Lago-Penas, & Gomez-Lopez, 2014). It was also expected that wide-midfielders and full backs would have more touches on the ball when compared to other positions (Carling, 2010). The results

from the current study support Carling (2010) as wide-midfielders had the most touches on the ball, probably because they dribble most frequently with the ball. Furthermore, based on the research conducted by Redwood-Brown et al. (2019) it was hypothesised that ball possession success rates will be around 75% successful. The results from this study indicated that soccer players ball possession success rate was 75%, supporting the findings of Redwood-Brown et al. (2019). In addition, the current study extends their work by showing success differences between playing positions. Centre-midfielders had greater success in ball possession (61.4 successful ball possessions), compared to centre-backs (37.9 successful ball possessions) and centre-forwards (31.9 successful ball possessions). Some explanation for centre-backs may be due to their role within the game of defending the goal and attempting to stop the opponents from scoring. A probable cause is defenders clearing the ball away from danger, therefore reducing the chances of making a successful pass.

Conclusion

Soccer players execute 2,103 (*SD* = 149) actions per match during English Premier League games, averaging 21.8 (*SD* = 1.5) actions per minute. They had 60 (*SD* = 20) ball possessions per match, of which 75% were successfully executed. More actions were executed in the first half (22.3 actions per minute (*SD* = 1.7)) compared to the second half (21.1 actions per minute (*SD* = 1.9)). More actions were executed when in possession of the ball (89.9 actions per min, (*SD* = 21.8)) and fewer actions were executed when the ball was out of play (11.1 actions per min, (*SD* = 2)) compared to other phases of play. Findings demonstrate the key role of decision-making during expert soccer match-play performance. This is the first study to assess cognitive load in soccer matches, therefore, there are implications for practice design so that training

actively stimulates the cognitive load found in match-play to facilitate transfer of learning. The training and preparation of players should incorporate decision-making activities that specifically replicate match play to enable them to perform successfully in future.

Chapter 3

Study 2

Abstract

One of the main tasks for coaches is to design and lead practice activities for their athletes in order to improve development and performance. The aim of this study was to examine the practice activities used by elite youth soccer coaches in England and for the first time to investigate the specificity of the practice activities they use. Thirty-six soccer coaches and their youth teams (n = 36 teams) took part in this study. They each led one of four teams at each of the three Category 1 English Football Association (FA) Youth Academies (YSA) of professional clubs, three Category 3 FA YSA and three local recreational football clubs. The four teams at each club consisted of two child (10 and 11 years of age) and two adolescent teams (15 and 16 years of age) to match the age stages used in the Premier League's Elite Player Performance Plan (EPPP). Three in-season sessions were filmed for each of the 36 coaches and their teams making a total of 108 sessions. The amount of session time spent in active decision making (ADM) and non-active decision making (NDM) activities was recorded. Three further variables were recorded in order to examine the specificity of the practice activities. First, pitch surfaces at each of the coaching session locations were categorised. Second, ADM activities were analysed to determine whether they contained match-play specific direction or not. Third, the size of the area the ADM activities were occurring on was measured based on the proportion of a full-size soccer pitch (7,140 square metres). The sessions contained 58.7 (SD = 19.7%) of ADM activity, 20.5 (SD = 18.5%) of NDM activity and 20.8 (SD = 7.4%) of transition between activities. Significant differences were found in ADM activity with greater amounts in child compared with adolescent teams. 96 out of 108 sessions (89%) were performed on artificial surfaces, whereas 12 out of 108 sessions (11%) were on natural grass. 39 out of 108 sessions (36%) were practiced in a quarter of the pitch, 44 out of

108 sessions (41%) were practiced in half of the pitch, with 25 out of 108 sessions (23%) practiced on a full pitch. For directional orientation, 189 out of 251 activities (75%) had direction towards a goal, whereas 54 out of 251 (22%) activities had no directional orientation and 8 out of 251 activities (3%) were multi-directional. The increase in ADM activity compared to previous research is probably due to modern coach education interventions that advocate a greater use of this activity in youth coaching sessions. However, the specificity of those activities was generally relatively low compared to match-play, potentially reducing transfer effects from practice to match-play.

Introduction

Coaches influence the development, performances and overall experience of their athletes (Ford, Coughlan, & Williams, 2009). Despite their obvious influence, there is debate within coaching and science as to what constitutes expert or effective coaching performance (Côté, Young, North, & Duffy, 2007). As a result, coaching performance and effectiveness have been measured using some less than reliable methods, such as win-loss records (Mallet & Côté, 2006) or the status and experience of the coach. However, many of the outcomes of coaching performance are demonstrated in the athlete, so its effects on them must also be accounted for (Ford et al., 2009). One of the main tasks for coaches is to design and lead practice activities for their athletes. In youth coaching, these practice activities should lead to relatively permanent skill acquisition in athletes that transfers to their improved performance in future competition. The aim of this study was to examine the practice activities used by youth soccer coaches in England and for the first time to investigate the specificity of the practice activities they use.

Coaches of team sports have been shown to use two types of activities in their practice sessions that have differential effects on skill acquisition in their athletes (Ford, Yates, & Williams, 2010; Low, Williams, McRobert, & Ford, 2013), particularly on the action executions measured in Study 1. Activities *without active decision making* (NDM) are those in which the coach pre-determines decisions for the athletes so that they are not actively making them when engaging in the practice, such as drill-based activity. NDM activities include fitness activity, technique practice and skills practices in which players are *not* active decision makers. In contrast, activities *with active decision making* (ADM) are those in which players are actively making decisions themselves based on the positioning of teammates, opponents and space.

ADM activities include small-sided games, unidirectional games, possession games, phases of play, full matches, and some skills practices in which players are active decision makers. ADM activity is predicted to lead to the greater transfer of perceptual-cognitive skills to competition activity compared to NDM activity (Ford, 2016). These skills include visual search, anticipation, and decision making, which have consistently been shown to differentiate experts from lesser-skilled athletes in team sports (for reviews, see Ford, 2016; Ford et al., 2010; Williams & Ford, 2013; Williams, Ford, Eccles, & Ward, 2011). However, team sport coaches use more NDM activity (training form) during practice sessions compared to ADM (playing form) (Ford et al., 2010; Low et al., 2013; see also Partington & Cushion, 2013). For example, 25 coaches of child and adolescent soccer teams from elite, sub-elite and recreational level in England had their players engage in NDM activity for 65% of session time and ADM activity for 35% of session time across 70 analysed coaching sessions (Ford et al., 2010). Similarly, Low et al. (2013) investigated the coaching sessions of child and adolescent cricket players at recreational and elite level in England. Players spent 69% of session time in NDM activity (drills) and 19% in ADM (games), with the remaining percentage of time spent in transition between the two activities, again with very few differences across skill or age groups. The effect on the athlete of engaging predominantly in NDM activity during coaching sessions is that acquired skill may not transfer successfully to improved competition performance (Ford et al., 2010).

A more recent study has shown a significant increase in the proportion of ADM activity during elite youth coaching sessions compared with that found previously (Ford et al., 2010; Low et al., 2013). O'Connor, Larkin and Williams (2017) used systematic observation tools to explore the sequencing of football coaching

sessions in Australia. A total of 66 coaching sessions were recorded from 34 youth soccer coaches (n = 19; U11-U13; n = 15; U14-U17). An adapted version of Ford et al.'s (2010) soccer practice activity coding system was used. Coaches had their players engage in 41% (SD = 14.8) ADM activity (playing form), 22% (SD = 13.4) NDM activity (training form), 31% (SD = 9.8) inactivity, and 6% (SD = 4.3) transitions between activities. It may be that newer coach education courses that encourage the use of ADM activity have led to these recent findings.

Representative Learning Design (RLD) involves designing practice, so the task and activities reflect the performance or competition environment (Pinder, Davids, Renshaw &, Araujo, 2011). RLD holds that training should be representative of the performance environment (e.g., match-play) and should be designed to contain key information sources that are necessary for the athletes to become attuned to the appropriate affordance for action so that acquired skill transfers successfully to that environment. Researchers have previously assumed that all ADM practice activities are equal in terms of their effects on the transfer of perceptual-cognitive skills from practice to competition activity. However, other variables are expected to contribute to the transfer of these skills from practice to competition activity, such as the *representativeness or specificity* of the practice. In this instance, specificity refers to the amount of similarity in conditions and player actions between the practice activity and the competition activity (Ford, 2016). Practice activities in team sports sometimes differ to competition activity and affect representativeness or specificity through variables such as pitch surface, playing area size, player numbers, and directionality.

A few factors influence practice representativeness or specificity in sport, particularly in soccer. First, artificial turf is now very common in many countries around the world (Andersson, Ekblom & Krustrup, 2008) and is frequently used for

training/practice in soccer, whereas most soccer matches (competition) are played on natural turf/grass. A few researchers have compared soccer performance on artificial turf with natural grass. Winterbottom (1985) found differences in ball bounce and ball roll between surfaces, with the ball bouncing higher and rolling further on artificial compared to natural grass. Additionally, players found it more difficult to start, turn and stop on artificial compared on natural grass. Andersson et al. (2008) examined the movement patterns, ball skills and impressions of Swedish elite football players during competitive games on artificial turf and natural grass. They made 16 team observations across 10 competitive matches. There were more short passes on artificial turf compared to natural grass (218 short passes, *s* = 14 *vs*. 167, (*SD* = 12)). The percentage of unsuccessful long high passes (58.9 long high passes (*SD* = 3.2) vs. 56.7 (*SD* = 1.6)) and of unsuccessful long low passes (36.6 long high passes (*SD* = 3.7) *vs*. 26.8 (*SD* = 3.1)) was greater on artificial compared to natural grass. Findings show artificial turf decelerates the ball less on passes into space when it strikes or rolls on the ground when compared to natural turf, leading to players executing more short passes directly to teammates. When combined, these findings demonstrate differences in some key actions between artificial turf and natural grass, likely reducing the specificity of and potentially some transfer between activities when practice/training occurs on artificial turf and matches occur on natural grass.

Second, many researchers and practitioners are interested in the use of small-sided and conditioned games as a method of facilitating learning in soccer. Small-sided games are modified games played in reduced pitch dimensions and/or space with fewer players when compared to matches. The design of these games and the manipulation of the rules by coaches can affect learning opportunities (Davids, Araujo, Correia., & Vilar, 2013). For example, Davids et al. (2013) examined the influence of pitch

dimensions in small-sided soccer games on grass soccer pitches, in shaping opportunities for performers to maintain ball possession, pass to teammates and shoot at goal. Amateur male participants (n = 15) played 5 *vs*. 5 small-sided soccer games in three varying pitch conditions: small, medium, and large. There were fewer opportunities to maintain possession on smaller pitches, when compared to medium and larger pitches. The different pitch dimensions did not influence opportunities for players to shoot at goal or to perform passes to other teammates. This research indicates that manipulated pitch dimensions of small-sided games might enhance opportunities for acquiring specific movement and decision-making skills. However, although researchers have not made comparisons, it could be expected that player actions and positioning in small-sided games would differ somewhat to those in full matches, such as shorter passes and less passes to space in small-sided games compared to matches.

Third, the directionality of some practice activities differs when compared to matches. Match play contains directionality in that each team attacks the goal of their opponent. In contrast, some practice activities in soccer do not contain directionality, such as possession games with no goals. Practice activities with no direction or multiple directions are different to the directionality found in match play, which could lead to differences in conditions and player actions that affect specificity between the two activities. Ometto, Vasconcellos, Cunha, Teoldo, Souza, Dutra, O'Sullivan and Davids (2018) published a systematic review investigating how manipulating task constraints in small-sided and conditioned games shapes the emergence of individual and collective tactical behaviours in football. Across the 24 articles in the review, five studies manipulated field dimensions, six manipulated the number of players involved, five manipulated field dimensions and number of players, five used scoring targets,

two altered the number of players and scoring target, and one manipulated the number of players, field dimension and scoring target. The main findings from this research were that as the dimensions of the field increased, players began to perform the following actions less frequently: scoring goals, dribbling, intercepting, putting the ball in play, and regaining possession of the ball. The decrease in dimensions of the field influenced the quality of the following tactical defensive behaviours; defensive coverage (less quality), concentration, and defensive unit (more quality). However, two studies revealed that, larger dimensions of the field, the larger the area that was occupied by teams. Consequently, there was a greater distance between players of the same team, as well as an increase in the distance between the players of the team in possession of the ball and their opponents. This research indicates that coaches have their players perform in different task constraints, therefore potentially changing the specificity of the activities.

The aim of this study was to examine the types of practice activities engaged in by youth soccer players in England and to investigate the specificity of those activities. Thirty-six soccer coaches and their youth teams took part in this study. There were two child and two adolescent teams from each of: three Category 1 English Football Association (FA) Youth Soccer Academies (YSA); three Category 3 FA YSA; and three local recreational football clubs. Three sessions per team were filmed and footage was analysed for the percentage of session time spent in ADM, NDM and transition, as well as measures of practice specificity, including surface used, size of the activity area, and directional orientation. It was expected that the amount of ADM would be greater than NDM activities when compared to that found by Ford et al., (2010). Additionally, it was also expected that the majority of training sessions would be practiced on artificial surfaces compared to grass pitches. Furthermore, based on

previous research it was predicted that most training sessions would be practiced on small- to medium-sized areas compared to large areas of the soccer pitch. Finally, it was also hypothesised that training sessions would predominantly contain directional practice activities, although the proportion with no direction would be relatively high.

Methods

Participants

Thirty-six soccer coaches and their youth teams (n = 36 teams) took part in this study. The coaches and teams were split into groups based on playing standard categories in the Premier League Elite Player Performance Plan (EPPP). They each led one of four teams at each of three Category 1 FA YSA at professional soccer clubs, three Category 3 FA YSA and three local recreational football clubs. Category 1 FA YSA are considered to be the highest attainment level of youth football in the EPPP, whereas Category 3 is a slightly lower level and recreational is considered the to be the "grass roots" level. The four teams at each club consisted of two child (10 and 11 years of age) and two adolescent teams (15 and 16 years of age) to match the age stages used in the EPPP. The research was conducted in accordance with the ethical guidance of the lead institution. Participants provided informed consent and were free to withdraw at any time.

Procedure

Coaching sessions. The coaching sessions took place at the training ground of each soccer academy or training facility as part of their normal training programme. Three in-season sessions were filmed for each of the 36 coaches and their teams using a digital video camera (Sanyo, VPC-SH1, California, USA) mounted on a tripod (Libec, Arizona, USA), making a total of 108 sessions. The video camera was

positioned on the side of the practice pitch at ground level in order to view all activity within the session.

Video analysis. The video footage of the coaching sessions was analysed for multiple variables using computer software (SportsCode Gamebreaker v. 8.5.2, Sportstec Limited, Carmarthenshire, United Kingdom). The start of the coaching session or activity was defined as the first movement when players started to physically engage in the first activity of the session. The end of the session or activity was defined as their final movement in the last activity. The amount of session time spent in ADM and NDM activities was recorded. ADM activities are those in which the main action execution decision/s for the player in possession of the ball has at least two or more degrees of freedom or options, mostly involving moving opposition and possibly teammates. ADM activities in soccer include skill practices in which players are active decision makers, small-sided or conditioned small-sided games, unidirectional small-sided games, possession games, and phases of play (Table 6.0) (Ford et al., 2010).

Table 6.0. Categories and definitions of soccer activities for active decision making (ADM).

Active Decision Making (ADM)	*Definition*
Skills (active)	Isolated technical or tactical skills from game situations in a small group with some opposition in which the players are active decision makers
Uni-directional game	Uni-directional in a small group towards one line (e.g., 2 *vs*. 1)
Small-sided game	Bi-directional with a team *vs*. team but with variations to player numbers, rules, goals, or areas of play (e.g., teams scoring by dribbling across end-line)
Possession games	Games with no goals in which the main intention is for one team to maintain possession of the ball from another
Phase of play	Uni-directional match play in a larger group towards one goal
Other	
Start of an activity	The first movement of the players to start physically engaging in the activity
End of an activity	The final movement of the players to end physically engaging in the activity

Transition	Movement from the end of one activity to the start of another activity. It is activity that is not football-related (e.g., drink breaks). This includes the coach's explanation of the forthcoming activity and debrief of preceding activity.

NDM activities are those in which the main action execution decision/s for the player in possession of the ball has only one degree of freedom or option. In NDM, the coach usually pre-determines the action selection decision or group of decisions for the player/s. NDM activities in soccer include fitness activity, technique practice, and skills practices in which players are *not* active decision makers (Table 7.0) (Ford et al., 2010).

Table 7.0. Categories and definitions of soccer activities for non-active decision making (NDM).

Non-active Decision Making (NDM)	*Definition*
Fitness	Improving fitness aspects of the game with no focus on technical or tactical skill (e.g., warm-up, cool down, conditioning)
Technical	Isolated technical skills unopposed either alone or in a group
Skills (non-active)	Isolated technical or tactical skills from game situations, in a small group with some opposition in which there is no active decision making for the players

Three further variables were recorded in order to examine the specificity of the practice activities. First, pitch surface types at each of the coaching session locations were recorded. Two categories were used to discriminate between surfaces: artificial and natural grass. Second, ADM activities were analysed to determine whether they contained match-play specific direction or not. Directional orientation was defined as an ADM activity in which two or more teams interact so that at least one team is attacking the territory of their opponent to score a goal or point (e.g., scoring into goals or dribbling into end zones). No directional orientation was defined as ADM activities that did not involve a team attacking opposition territory to score (e.g., possession games). Third, the size of the area the ADM activities were occurring on was measured based on the proportion of a full-size soccer pitch (7,140 square metres). Three categories were used to discriminate between the size the practice activity was performed in: small practices performed in a quarter of a full-sized soccer pitch (1,785 square metres), medium practices performed in half of a soccer pitch (3,570 square metres) and large practices performed on a full pitch (7,140 square metres). The same pitch size measuring system was used for both child and adolescent practice activities.

Observer reliability. Observer reliability was assessed by reanalysis of a proportion (25%) of the coaching sessions for all variables by the lead researcher (intra) and another trained researcher (inter) a week after the first analysis occurred. Intra- and inter-observer agreements between the repeated observations were calculated using the equation: (Agreements / (Agreements + Disagreements)) x 100. Intra-observer reliability was calculated to be 96% and inter-observer reliability was 96%, which both exceed the standard acceptance level of 85% (Darst, Zakrajsek & Mancini, 1989).

Data analysis

Coaching sessions. The 108 coaching sessions were separated by age and skill level as independent variables. Age groups were sessions with either child players (10 and 11 years old) or adolescent players (15 and 16 years old). Skill groupings were sessions with Category 1 FA YSA, Category 3 FA YSA or recreational teams, thereby creating six groupings. Mean session duration was calculated as a function of age and skill group. The percentage of session time spent in ADM and NDM activities was calculated, as well as that spent in transition between ADM and NDM activities. As ADM activities were the largest category, inferential statistics were conducted on this variable.

Practice specificity. Three measures of practice specificity were recorded**.** First, the frequency of practice sessions on each of the two pitch surface categories (artificial or natural grass) were analysed. Second, the size of each of the practice activities was categorised (small, medium, large). Third, the frequency and percentage of time in ADM activities with or without directional orientation were analysed. ADM activities with directional orientation were split into those with normal rules or multi-directional (Table 8.0).

Table 8.0. Definitions of directional orientation.

Directional Orientation	An ADM activity in which two or more teams interact so that at least one team is attacking an opponent's territory to score a goal or point, such as scoring into a goal or dribbling into an end zone.
Normal Rules	ADM activities in which two or more teams interact so that both teams are attacking each other opponent's territory to score a goal, for example scoring into a goal.
Multi-directional	ADM activities in which two or more teams interact so that at least one team is attacking an opponent's territory to score a goal or point, such as scoring a goal, dribbling into an end zone, into at least one goal or end zone.
Possession	ADM activities in which two or more teams aim to maintain control of the ball or as long as possible without any goals or direction.

Results

Coaching sessions. Mean session duration across the 108 coaching sessions was 76.3 ± (*SD* = 23.4) minutes. Figure 4.0 shows the percentage of time that players spent in ADM activity, NDM activity, and transitions between activities across the six teams. The sessions contained 59 (*SD* = 20%) of ADM activity, 21 (*SD* = 19%) of NDM activity and 20 (*SD* = 7%) of transition between activities.

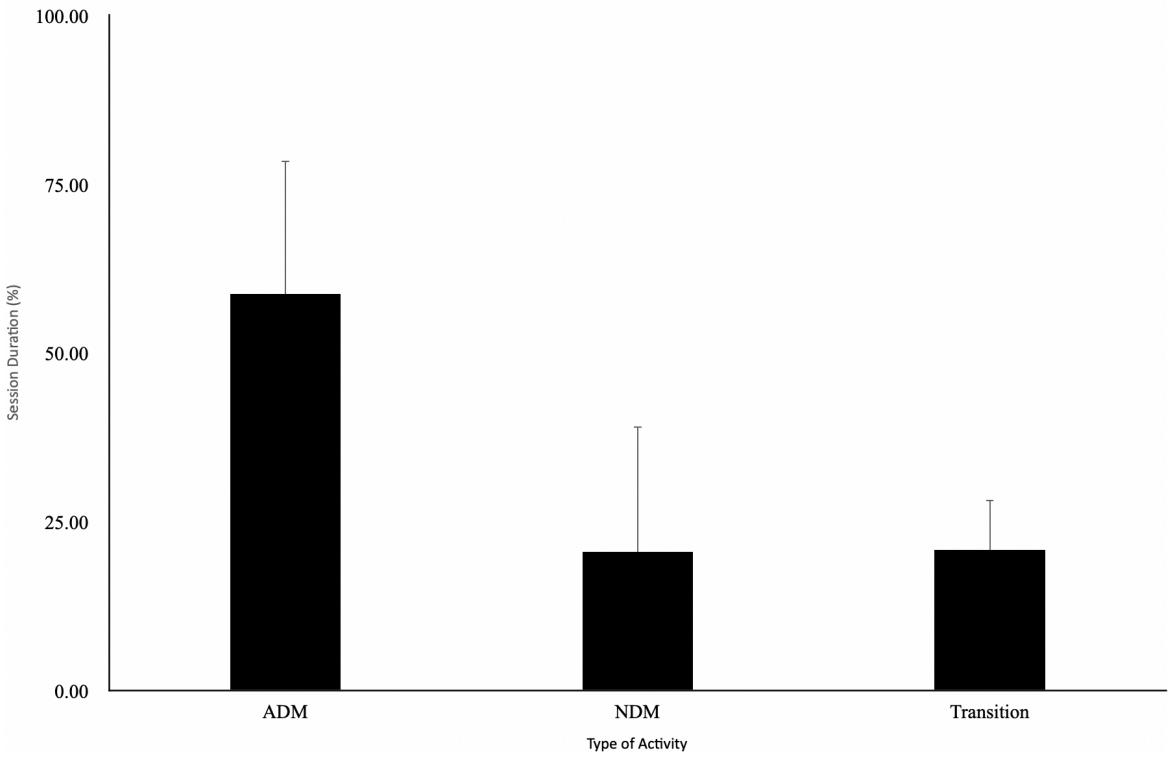

Figure 4.0. Percentage of time that players spent in ADM activity, NDM activity, and transitions between activities across the six teams.

An independent *t*-test revealed a significant difference in ADM activity between child and adolescent teams, $t_{106} = 1.2$, $P < 0.05$. The 95% CI for the mean difference was -3% to 12 %. The mean percentage of ADM activity for childhood teams (61%, (*SD* = 15)) was greater than for adolescent teams (56%, (*SD* = 24)). A

one-way ANOVA revealed that there was no significant difference in ADM activity between playing standards ($F_{2, 105} = 0.77$, $P = 0.463$).

An independent *t*-test revealed no significant difference in the duration of child and adolescent sessions, $t_{106} = 0.9$ $P < 0.05$. The 95% CI for the mean difference was -4.8 minutes to 13.06 minutes. A one-way ANOVA revealed there was a significant effect of academy category on session duration ($F_{2, 105} = 103.6$, $P < 0.05$). Category 3 session mean duration (96.6 mins, ($SD = 11.6$)) was significantly greater than mean session duration of Category 1 (81.3 mins, ($SD = 17.6$)) and Recreational (50.9 mins, ($SD = 10.8$)) teams

Practice specificity

Surface type. Overall, 96 out of 108 sessions (89%) were on artificial surfaces, whereas 12 out of 108 sessions (11%) were on natural grass. For child teams, all 54 sessions (100%) were on artificial surfaces, whereas for adolescent teams 42 out of 54 sessions (78%) were on artificial surfaces with 12 out of 54 sessions (22%) on natural grass. Natural grass was used more in YSA when compared to recreational sessions, with 6 out of 36 sessions (17%) on natural grass for each of Category 1 and 3 YSA, whereas no sessions were on natural grass for recreational teams.

Pitch size. 39 out of 108 sessions (36%) were practiced in a quarter of the pitch, 44 out of 108 sessions (41%) were practiced in half of the pitch, with 25 out of 108 sessions (23%) practiced on a full pitch. For child teams, 26 out of 54 sessions (48%) were practiced in a quarter of the pitch, 24 out of 54 sessions (44%) were practiced in half of the pitch, with 4 out of 54 sessions (8%) practiced on a full pitch. For adolescent teams, 13 out of 54 sessions (24%) were practiced in a quarter of the pitch, 20 out of 54 sessions (37%) were practiced in half of the pitch, with 21 out of

54 sessions (39%) practiced on a full pitch. Quarter of a pitch was used more by recreational teams (83% of sessions) compared to YSA teams (5% for Category 1 and 19% for Category 3), whereas a full pitch was used more by Category 1 (42%) when compared to the other teams (28% for Category 3 and 0% for recreational) (Table 9.0).

Table 9.0. Percentage of pitch size used.

Age Group & Category Type	*Quarter of a pitch*	*Half of a pitch*	*Full pitch*
Child & Adolescent	36%	41%	23%
Child	48%	44%	8%
Adolescent	24%	37%	39%
Category 1	5%	53%	42%
Category 3	19%	53%	28%
Recreational	83%	17%	0%

Directional orientation. 189 out of 251 ADM activities (75%) had direction towards a goal, whereas 54 out of 251 (22%) ADM activities had no directional orientation and 8 out of 251 activities (3%) were multi-directional, with few, if any, differences between the two age groups or skill groups (Table 10.0).

Table 10.0. Percentage of directional orientation.

Age Group & Category Type	*Direction towards a goal*	*No direction towards goal*	*Multi-directional*
Child & Adolescent	75%	22%	3%
Child	75%	20%	5%
Adolescent	75%	24%	1%
Category 1	76%	21%	3%
Category 3	71%	25%	4%
Recreational	80%	18%	2%

Discussion

The aim of this study was to examine the types of practice activities engaged in by youth soccer players in England and the opportunities for them to practice the decision making measured in Study 1, as well as to investigate variables related to the specificity of those activities compared to match-play. Thirty-six soccer coaches and their youth teams took part in this study across two age groups (child, adolescent) and three categories (1, 3, recreational). Three sessions per team were filmed and footage was analysed for the percentage of session's time spent in ADM, NDM and transition, as well as measures of practice representativeness or specificity, including turf used, size of the activity area, and directional orientation.

It was expected that the amount of ADM has increased and would be greater than NDM activities when compared to that found by Ford et al. (2010). Our findings show that the amount of ADM activity used by coaches of youth players in their sessions has increased compared to that found in the Ford et al. (2010) study. In the Ford et al. (2010) study the amount of ADM activity for the elite teams across age groups was 40% of session time. In this current study, the amount of ADM activity across age groups was 59% of session time on average. Additionally, research by O'Connor et al. (2017) found that soccer coaches in Australia had their players engage in 41% of ADM activity during training sessions. Furthermore, previous research by Low et al. (2013) found that only 19% of session time was spent in ADM activity in cricket, far lower than found in this current study. The increase in ADM activity is probably due to modern coach education interventions that advocate a greater use of this activity in youth coaching sessions. Coach education interventions are association led courses that aim to develop and change coach behaviours.

Based on the popularity of artificial turf in many countries around the world (Andersson, Ekblom & Krustrup, 2008), along with the lack of availability of grass pitches and their protection/maintenance, it was expected that most training sessions would be practiced on artificial surfaces compared to grass pitches. As predicted more coaching sessions (89%) were performed on artificial pitches when compared to natural grass. Finding suggests a lack of specificity in playing surface between training and match play that may attenuate the transfer of skill between the two activities. For example, Winterbottom (1985) found the ball bounced higher, rolled further and players had greater difficulty executing fast movements on artificial computed to natural grass. Moreover, Andersson et al. (2008) found more short passes and unsuccessful long passes on artificial turf compared to natural grass. These differences in technical and movement actions between artificial turf and natural grass reduce specificity and potentially transfer of skill between the two activities when practice/training occurs on artificial turf and matches occur on natural grass.

It was expected that most training sessions would be practiced on small- to medium-sized areas compared to large areas of the soccer pitch. As predicted, more coaching activities (77%) were practiced in small- (a quarter of the pitch, 36%) and medium-sized pitches (half of the pitch, 41%) compared to a full pitch. Davids et al. (2013) examined the influence of pitch dimensions in small-sided soccer games on grass soccer pitches in three varying pitch conditions: small, medium and large. They found that there were fewer opportunities to maintain possession on smaller pitches and more ball possessions, when compared to medium and larger pitches. Findings indicate that manipulated pitch dimensions of small-sided games may enhance opportunities for acquiring specific movement and decision-making skills. However, it could be expected that player actions and positioning in small-sided games would

differ somewhat to those in matches, such as shorter passes and less passes to space in small-sided games, reducing the specificity of these practice activities. Research by Ometto et al., (2008) identifies different demands placed on physical, technical and tactical behaviour when pitch size alters. Additionally, these can have impact on tactical behaviours when adding direction. For example, if the pitch is too small, players will often not be able to complete passes that encourage "running in behind opponent defences".

It was expected that most training sessions would predominantly contain directional practice activities, but that the proportion with no direction would be relatively high. As predicted 189 out of 251 activities (75%) had direction towards a goal, whereas 54 out of 251 (22%) activities were possession based and not practiced towards a goal for all teams combined, with 8 out of 251 activities (3%) being multi-direction towards a goal. Match-play contains directionality in that each team attacks their opponent goal. On the other hand, some practice activities in soccer do not contain directionally, such as possession games. Findings indicate that coaches have their players engage mostly in coaching sessions that have direction (75%). However, practice activities with no direction or multiple directions are engaged in frequently and are different to the directionality found in match play, which could lead to differences in conditions and player actions that affect specificity between the two activities. No research has been conducted to compare and contrast to these findings within this study.

Conclusion

Soccer coaching sessions contained 58.7% of ADM activity, 20.5% NDM activity and 20.8% was spent in transition between activities. Significant differences

in the use of ADM activity were found between child and adolescent age groups, however there were no significant differences found between academy categories. 89% of sessions were performed on artificial surfaces with only 11% performed on natural grass. Coaches had their players perform in medium practices (half of a pitch) for 41% of the time, 36% in small practices (quarter of a pitch) and 23% of sessions performed in large practices (full pitch). Finally, 75% of coaching sessions had direction towards a goal, whereas 22% of activities had no directional orientation. 3% of activities used a multi-directional approach.

In future, coaches should seek to further increase the amount of ADM activity by reducing transition time between activities and converting NDM activities into those in which players are active decision makers as per match-play. Moreover, some of the ADM activities analysed appeared to lack specificity because players were making movements, actions and decisions that looked and were different to those they make during match-play. There did not appear to be a systematic approach by the coaches to ensure players experienced the repetition of attempts at all the key skills, situations and tactics that form the game and that are required for skill acquisition to occur. Coaches should seek to increase the amount of representativeness or specificity during practice activities by increasing the number of coaching sessions performed on grass and increasing the amount of practice activities on larger-sized football pitches appropriate to the age-group.

Chapter 4

Study 3

Abstract

Active decision making (ADM) activity is expected to lead to greater improvements in the ability of players to use vision to scan the match-play environment and to make decisions when compared to non-active decision making (NDM) activity. The aim of this study is to examine the effectiveness of a coaching course in increasing the amount of ADM activity used in youth coaching sessions and the associated effect of any change to coach behaviour on visual scanning and decision making by players during small-sided games. Three coaches who took part in the coaching course and their U11 elite players participated. They were filmed for three coaching sessions prior to and three sessions after the course. The video of the sessions was analysed for the proportion of time spent in ADM, NDM and transition between the two activities. Moreover, after each of the three coaching sessions before and after the course, the players took part in an 8 *vs*. 8 small-sided game that was filmed. Analysis of course content and semi-structured interviews with the coach educators were conducted. The main aim of the course was to increase the amount of ADM activity in youth coaching sessions and to increase visual scanning in players. ADM activity significantly increased by 18% after compared to before the course, whereas NDM activity significantly decreased by 10%. Coaches cited reasons for this change were their participation on the course, making their training sessions more game-realistic, attempting to develop the decision making of their players, and external reasons, such as the club curriculum. Game footage was analysed for visual search and success of decision making. There was significantly more visual scanning and more successful decision making in the games after compared to before the course. The course appears to have led to the coaches increasing the amount of ADM activity they used in their sessions. During the same time period, the visual scanning and decision

making of the players improved significantly, maybe as a function of the increase in ADM activity following the course.

Introduction

Study 1 quantified the frequency and type of action executions during match-play, resulting in a high amount of action executions by professional soccer players during match-play. Study 2 examined the practice activities used by youth soccer coaches to show that the players engage in practice activities with the high decision making and action execution load found in Study 1. Therefore, Study 3 was designed to examine the acquisition of decision making and action executions in youth players, and how this is related to changes in the practice design of their coaches that might result from their engagement on a coach education course.

Practice plays an important role in skill acquisition, although not all practice is of equal quality. Researchers (Ford, Yates, & Williams, 2010; Low, Williams, McRobert, & Ford, 2013) have examined the practice or coaching sessions of elite youth players. They have found that the practice activities used in coaching sessions can be split into two categories that have differential effects on skill acquisition. Non-active Decision-Making activities (NDM) are mainly drill-based activity in which the coach pre-determines the decisions for players so that they are not actively making them when engaging in the practice activities. NDM activities include fitness training, technique, and some skills practices. Active Decision-Making activities (ADM) are those in which players are actively making decisions themselves based on the positioning of teammates, the opposition and space. ADM activities include small-sided games, unidirectional games, possession games, some skill practices, and phases of play. ADM activity is predicted to lead to greater improvements in the ability of

players to use vision to scan the match-play environment and to make decisions when compared to NDM activity (Ford et al., 2010; Williams & Ford, 2013; Low, Williams, McRobert, & Ford, 2013).

Findings across studies (Ford et al, 2010; Low et al, 2013; Partington & Cushion, 2013) that have assessed the relative amounts of these two activities in youth coaching sessions show players engage in greater amounts of NDM compared to ADM activity, which is likely leading to attenuated skill acquisition when transferring to match-play. Conversely, researchers in Australia have found that there has been a change in the proportion of ADM and NDM activities compared to previous research (Ford et al., 2010; Low et al., 2013). O'Connor et al. (2017) used a systematic observation tool to explore the structure (i.e., activity and inactivity) and sequencing (i.e., the types of activities used) of football coaching sessions in Australia following the implementation of a new national curriculum. Youth soccer coaches (n = 34), coaching within the skill acquisition (U11-U13, n = 19) and game training (U14-U17, n = 15) phases of the Football Federation Australia National Curriculum participated. Participants were filmed during regular coaching sessions, with systematic observation of session undertaken to provide a detailed analysis of the practice activities and coach behaviours. ADM activities accounted for 41% of session time compared to 22% NDM activities. Modern coach education interventions advocating greater use of ADM activities were cited as a reason for this difference to earlier studies.

In 2010, the FA launched 'The Future Game' guide in which an aim is 'to produce technically excellent and innovative players with exceptional decision-making skills' (p.5, The FA, 2010). The FA have launched coaching courses with content designed to achieve this aim, such as The FA Advanced Youth Award and The FA Youth Award Modules. In part, these courses are thought to advocate that coaches

increase the amount of ADM activity used in their coaching sessions so as to improve the ability of players to use vision to scan the match-play environment (e.g., McGuckian, Cole, Jordet, Chalkley & Pepping, 2018) and to make decisions involving anticipation of advance cues, pattern recognition, and action selection. Ideally, content delivered on the coaching courses leads to a relatively permanent change in coach behaviour that, subsequently, leads to skill acquisition in players (Ford, Coughlan, & Williams, 2009). For example, coaching content that advocates increasing the amount of ADM activity used in coaching sessions should lead to coaches who participated in the course using more of this activity in their sessions and, subsequently, improving player ability to use vision to scan the environment and to make decisions during match-play.

To fully understand coaching, researchers must not only examine what coaches do, but also the reasons that underpin what they do and where they acquire their knowledge and behaviours from (Ford et al., 2009). Some researchers have investigated why coaches use the activities they have athletes engage in and where they acquire their knowledge from. For example, Partington and Cushion (2013) interviewed 11 elite youth soccer coaches in England about why they use the activities they had players engage in. Coaches stated that they used NDM activities due a lack of pitch space in which to use ADM activities. They further stated they used their practice activities to develop decision making in players. Whilst no researchers have examined the sources that coaches first acquire the activities they use during their sessions, other researchers (Erickson, Bruner, MacDonald, & Côté, 2008; Wright, Trudel, & Culver, 2007) have investigated general sources of coaching knowledge. Wright et al. (2007) interviewed 35 volunteer youth ice hockey coaches in Canada about the sources of their coaching knowledge. Coaches reported that their knowledge

was acquired from coach education courses, coaching experiences, books/videos/internet, and through interacting with other coaches including mentors. Similarly, Erickson et al. (2008) interviewed 44 coaches working across various sports and age groups in Canada about the sources of their knowledge. Coaches stated that their knowledge was acquired by "doing" coaching, from coach education, from printed and electronic material, and by observing and interacting with other coaches including mentors. It is likely that the acquisition and designing of practice activities by coaches for their practice sessions occurs from the same or similar sources. Findings from the Erickson et al. (2008) and Wright et al. (2007) show that coaches acquire both craft and professional knowledge. Professional knowledge is based on relatively certain scientific evidence and theories and is often disseminated through coach education. Craft knowledge is described as "knowing-in–action" as it is practical knowledge that guides the various steps and actions of the performance itself (Ford et al., 2009).

The aim of this study is to examine the effectiveness of a coaching course in changing coach behaviour and, subsequently, player skill acquisition. Three coaches took part in the coaching course with their U11 elite players taking part in the study. They were filmed for three coaching sessions prior to and three sessions after the course. The video of the sessions was analysed for the proportion of time spent in ADM, NDM and transition between the two activities. Following the final block of sessions, the coaches were interviewed about their reasons for using the types of practices activities from pre- to post-test. Moreover, after each of the three coaching sessions before and after the course, the players took part in an 8 *vs*. 8 small-sided game that was filmed. Game footage was analysed for the perceptual-cognitive skills of visual scanning behaviour and decision-making success. It is expected that the

coaching course will advocate and, subsequently, lead to an increased amount of ADM activity in practice sessions occurring after the course compared to before it, with an associated increased in the amount of visual scanning and successful decision making by players during small-sided games after the course and sessions compared to before it. Coaches were expected to cite the course and information from it as their reason for increasing ADM activity after it.

Method

Participants

Participants were three coaches of elite players aged 10-11 years in three separate Youth Academies of professional soccer clubs in England. The research was conducted in accordance with the ethical guidance of the lead institution. Participants provided informed consent and were free to withdraw at any time.

Procedure

The coaches participated in The FA Advanced Youth Award in 2018. Prior to the course, the three coaches participated in a pre-test, and, following the course, a post-test. Prior to the course in the pre-test, three coaching sessions from each of the three coaches were video recorded, making a total of nine sessions. Video footage was analysed for the relative amount of time spent in ADM and NDM activity, as well as the transitions between the two activities (see Table 11.0).

Table 11.0. Categories and definitions of soccer activities for active decision making (ADM) and non-active decision making (NDM).

Active Decision Making (ADM)	*Definition*
Skills (active)	Isolated technical or tactical skills from game situations in a small group with some opposition in which the players are active decision makers
Uni-directional game	Uni-directional in a small group towards one line (e.g., 2 *vs*. 1)
Small-sided game	Bi-directional with a team *vs*. team but with variations to player numbers, rules, goals, or areas of play (e.g. teams scoring by dribbling across end-line)
Possession games	Games with no goals in which the main intention is for one team to maintain possession of the ball from another
Phase of play	Uni-directional match play in a larger group towards one goal
Non-active Decision Making (NDM)	*Definition*
Fitness	Improving fitness aspects of the game with no focus on technical or tactical skill (e.g. warm-up, cool down, conditioning)
Technical	Isolated technical skills unopposed either alone or in a group

Skills (non-active)	Isolated technical or tactical skills from game situations, in a small group with some opposition in which there is no active decision making for the players
Other	
Start of an activity	The first movement of the players to start physically engaging in the activity
End of an activity	The final movement of the players to end physically engaging in the activity
Transition	Movement from the end of one activity to the start of another activity. It is activity that is not football-related (e.g. drink breaks). This includes the coach's explanation of the forthcoming activity and debrief of preceding activity.

Moreover, after the three coaching sessions, the players of each coach took part in three separate internal 8 *vs*. 8 games that were filmed. Game footage was analysed using a tool that measures the frequency of visual search and scanning, and decision making during a game. The development and validation of the analysis instrument for the analyses of the games followed the process outlined by Brewer and Jones (2002) (see Chapter 3). The sequential stages prior to the analysis were: (i) the development and validation of the notation analysis instrument and its categories; (ii) observer training; and (iii) establishing the objectivity and reliability of the observer. Two experienced performance analysts and a coach within the research team created the analysis instrument or tool to examine the frequency of visual scanning and the frequency and success of ball possessions the soccer players performed during the 8 *vs*. 8 games. The performance analysts and coach had an average of 7.7 (*SD* = 1.2) years of experience working in professional soccer. To ensure logical validity and remove the individual bias of the research team, the panel reviewed the definitions used in the coding instruments. The panel provided written feedback and agreed that the definitions were appropriate for analysing visual scanning and ball possessions.

Visual scanning is the act of constantly moving gaze around a soccer pitch to perceive the positioning and movements of teammates, opposition, and space (Williams & Ford, 2013). Small-sided game footage was analysed for the frequency of visual search and scanning conducted by the players. The frequency of head turns by each player in the games was used as a proxy for visual scanning, as per previous research (e.g., McGuckian et al, 2018). Head turns by players were defined as a body and/ or head movement in which the face is actively and temporarily directed away from the ball, with the intention of looking for information that is relevant to perform a subsequent action with the ball. It has been reported that a higher frequency of

exploratory head turns up to 10-s before receiving the ball increases the likelihood of successful performance when in possession of the ball (McGuckian et al, 2018).

The tool used for measuring the success of ball possession was a slight variation of the tool used in Study 1. Ball possessions were defined as the player being in possession of the ball. The success of possessions that involved passes, attempts at goal and dribbles were measured. Passes were attempts to play the ball to a teammate via a short pass, long pass and/or a headed pass. Successful passes were defined as when the ball is passed, thrown, or headed to a teammate and he attempts to or does take control of the ball using part of his body. Successful attempts at goal (with any part of the body) were defined as those on target, including goals and saves within the posts by the opposition goalkeeper. Successful dribbles were defined as those that beat a player/s or lead to the awarding of a free kick. Clearances and headers that are not shots or passes and kicking the ball to the opposition goalkeeper to restart play or out of play for an injured player, were all excluded. Unsuccessful possessions were defined as when a ball is a kicked, controlled, dribbled, thrown, or headed, but is regained by the opposition or goes out of play or hits the goal frame. Clearances and headers that are not shots or passes are excluded.

Data was recorded for 17 players who participated in both small-sided games during the pre- and post-test. Players who took part in either the pre-test game only or the post-test game only were removed from the analysis. Subsequently, the coaches took part in The FA Advanced Youth Award course (AYA). During the course, the coach educators were interviewed about the main goals of the content on the course in this area. Moreover, the course content was analysed to reveal the main goals in this area. Immediately following the course, the coaches and their players took part in the post-test, which was the same as the pre-test. Additionally, in the post-test, semi-

structured interviews were conducted with the coaches in an attempt to reveal what they had learnt from the course and to provide rationales for their coach behaviour during the post-test (see Figure 5.0 and 6.0).

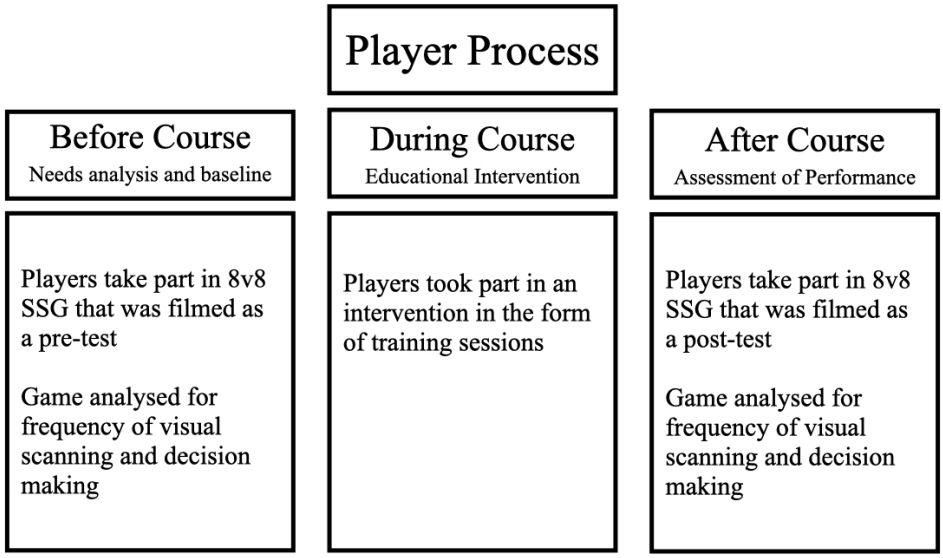

Figure 5.0. Shows the methodology and process used for players during the analysis process.

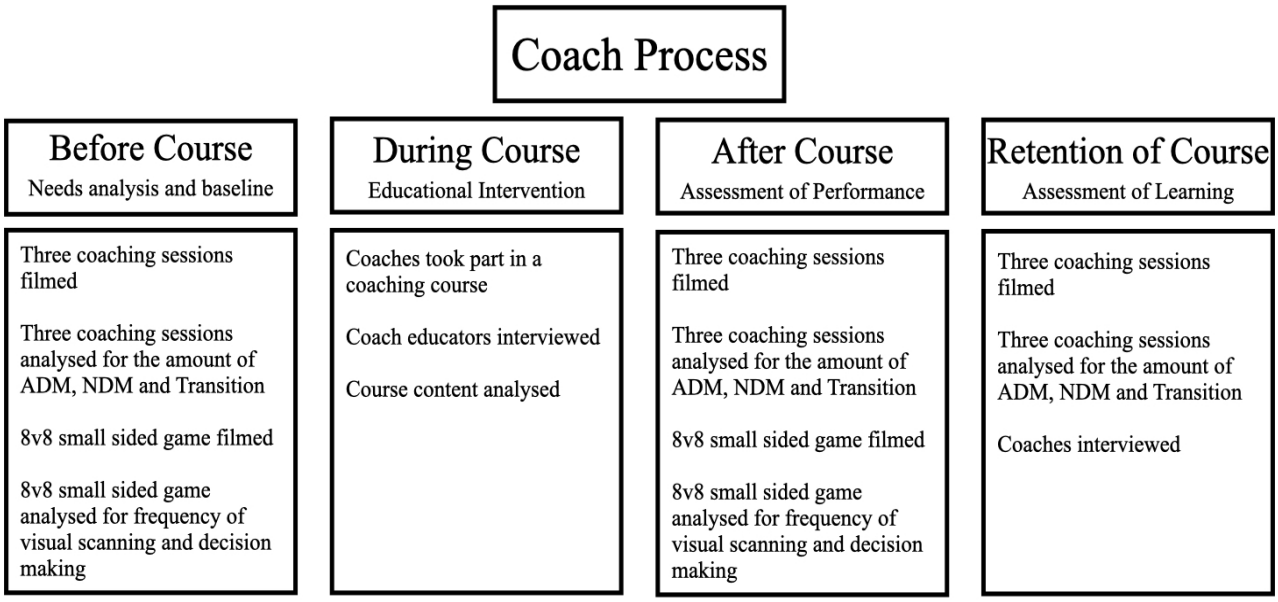

Figure 6.0. Shows the methodology and process used for coaches during the analysis process.

Data analysis

Six data sets were extracted from the analysis: (i) proportion of coaching time spent in ADM activity, NDM activity, and transitions; and in games (ii) frequency of visual scanning by players (iii) frequency of ball possessions, (iv) touches of the ball, (v) success rates of ball possessions. For interviews (vi) response categories were created and their frequency recorded for coaches when asked 'the reasons for using more ADM activities in the post-test sessions compared to the pre-test sessions?' was analysed. Paired *t*-tests were conducted to compare between pre- and post-test the percentage of ADM activity and for the small-sided games the frequency of ball possessions, touches of the ball and success rates of ball possessions. Frequency of themes was used for analysing coach interviews.

The alpha level for significance was set at $P < 0.05$.

Results

Practice activities

Figure 7.0 shows the proportion of coaching session time spent in ADM activity, NDM activity, and transitions between activities across the pre- and post-test. In the pre-test, the mean duration of the sessions was 85 minutes (*SD* = 10), whereas in the post-test mean duration was 76 minutes (*SD* = 15). During the pre-test, the sessions contained 49% (*SD* = 8) of ADM activity, 30% (*SD* = 7) of NDM activity, and 21% (*SD* = 5) of transition between activities. During the post-test, the sessions contained 67% (*SD* = 9) of ADM activity, 11% (*SD* = 9) of NDM activity, and 22% (*SD* = 9) of transition between activities. Mean ADM activity was significantly greater in the post- (67%, *SD* = 9) when compared to the pre-test (49%, *SD* = 8), $t_8 = -3.9$, *P*

< 0.05. Mean NDM activity was lower in the post- (11%, (*SD* = 9)) when compared to the pre-test (30%, (*SD* = 7)), $t_8 = 4.1$, $P < 0.05$.

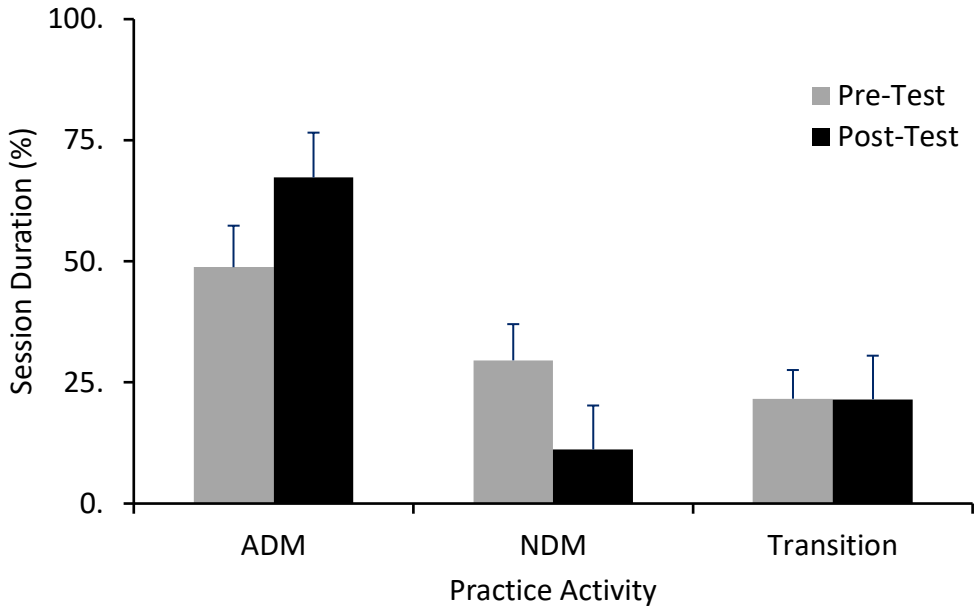

Figure 7.0. The proportion (%) of time spent in Active Decision-Making activity (ADM), Non-Active Decision-Making activity (NDM), and transitions between activities during the sessions of the U11 teams at the three clubs in the pre- and post-test.

Small-sided game player performance

In the pre-test, the average duration of the small-sided games was 21 minutes (*SD* = 4), whereas in the post-test mean duration was 19 minutes (*SD* = 6).

Visual scanning. The small-sided games in the pre-test contained an average of 106 head turns per player (*SD* = 28), equating to 5.1 head turns per minute. The small-sided games in the post-test contained an average of 118 head turns (*SD* = 29), equating to 6.6 head turns per minute. The number of head turns per minute was significantly greater in the post-test (6.6 head turns per minute, *SD* = 1.5) when

compared to the pre-test (5.1 head turns per minute, *SD* = 1.6), t_{16} = -4.4, $P < 0.05$, showing the amount of visual scanning was greater following the course compared to before it.

Decision making. There was a significant difference between the pre- and post-test in frequency of ball possessions, t_{16} = 3.23, $P < 0.05$. The mean number of ball possessions was greater in the pre- (27.2 ball possessions, (*SD* = 7.7)) when compared with the post-test (21.4 ball possessions, (*SD* = 9.8)). The 95% CI for the mean of differences was from 1.9 to 9.5 ball possessions. There was a significant difference between the pre- and post-test for frequency of touches on the ball, t_{16} = 2.26, $P < 0.05$. The mean number of touches on the ball was greater in the pre-test (51.4 touches, (*SD* = 15.8)) when compared with the mean for the post-test (39.8 touches, (*SD* = 14.8)). The 95% CI for the mean of differences was from 0.7 to 22.5 touches on the ball.

During the pre-test, players had a mean of 27.2 (*SD* = 7.7) ball possessions, of which 19.9 (*SD* = 5.3) were successful, equating to a success rate of 73%. During the post-test players had a mean of 21.4 (*SD* = 9.8) ball possessions, of which 16.2 (*SD* = 7.6) were successful, equating to a success rate of 76 %. There was a significant difference between the pre- and post-test percentage success rate, t_{16} = -2.6, $P < 0.05$. The mean percentage success rate was greater in the post-test (76%, (*SD* = 16.5)) when compared with the pre-test (73%, (*SD* = 7.9)). The 95% CI for the mean of differences was from -2.0 to -23.4 percentage success rate.

Coach interviews

The coaches of the three U11 teams were interviewed about the reasons they used more ADM activities in the post- compared to the pre-test. Table 12.0 shows the

type and frequency of responses from the coaches to this question. The main reasons from the coaches for increasing the amount of ADM activities was because of their participation on the coaching course, making their training sessions more game-realistic, attempting to develop the decision making of their players, and external reasons such as the club curriculum.

Table 12.0. The type and frequency of responses from the coaches of U11 teams at the three participating clubs when asked 'the reasons for using more games-based activities in the post-test sessions compared to the pre-test sessions?'

Response	Frequency	Example Quote
Influence of the AYA Course	7	"Due to the Advance Youth Award, then discussion with the head of coaching, where we made a conscious decision to go down the route of more games-based practices within the foundation phase."
Game-realistic	4	"Ultimately the week is spent preparing for the games on a Sunday, that's where we want to see the boys performing, we want to see progression and we want to make sure the things we have worked on in the week are coming out in the games. We want to try and make it as real to the game on a Sunday as we possibly can within training."
Enhance decision making	2	"In the past we have been very drill-based, however we are now trying to produce players that are comfortable on the ball or staying on the ball but also for them to become good decision makers in possession, out of possession but also having their own influence as it's about the players not the coaches, the random practice for me is key to go out and allow the players to express themselves."

Club Curriculum	1	"What we've done for this season is instead of having two coaches per age group we are now employing individual coaches, these coaches will take the players on a one to one basis to work on any technical details we have identified that needs working on, so this gives use chance to work on more of the games based activities."
Total	**14**	

Course content

A content analysis was conducted on the course booklet to assess the information provided to the coaches regarding the topics of practice structure, decision making and visual scanning. Table 13.0 shows the frequency of information on these topics within the course booklet. The course booklet highlighted in numerous places the importance of using ADM activities and contained many examples of ADM practice activities. Additionally, the importance of decision making and practice structure in youth football was highlighted on numerous occasions. There was only one example activity in the booklet that was categorised as NDM activity, whereas 15 activities were categorized as ADM. The Future Game DVD and Future Game USB stick for the 8-11 Foundation Phase provided to the coaches was analysed to determine the types and frequencies of activities that were provided to the coaches during the course. Table 14.0 shows the amount of ADM and NDM activities used within these resources. The DVD and USB stick contained 37 examples of ADM practice activities and 5 examples of NDM activities.

Table 13.0. The type and frequency of information provided within the Advanced Youth Award course booklet.

Information	Frequency	Example Quote
Designing practice & structure	19	"The design of the practice should challenge players to 'scan', 'assess' and 'anticipate' the movement of the ball, team-mates and the opposition. Monitoring the game in this way will help players improve their sense of awareness and understanding of space and time, which in turn will improve their decision making and technical execution".
Example of ADM practices	15	Detailed session plans of Active Decision-Making practices were present throughout the course booklet.
Importance of decision making	11	"Developing game understanding and decision-making should be encouraged in this age group. Players should be given lots of opportunity to take part in game-related practice, with coaches challenging players to solve problems within small-sided games".
Importance of practice structure	2	"Most expert football players are products of a life-long dedication to self-improvement, accumulating thousands of hours of practicing and playing games along the way".

Questionable practice structure	1	“Some players will need more constant practices”.
Example of NDM practices	1	One example of Non-Active Decision Making was present within the course booklet.
Total	**49**	

Table 14.0 The type and frequency of practice activities used on the Future Game DVD and Future Game USB for the 8-11 Foundation Phase.

Topic	Active Decision-Making (ADM)	Non-Active Decision-Making (NDM)
Attacking Play	17	0
Ball Mastery	3	5
Counter Attacking	2	0
Defending the Goal	5	0
Possession Play	10	0
Total	**37**	**5**

Coach educator interviews

During the course, semi-structured interviews were conducted with three of the coach educators who were leading the course to understand the information they provided to or extracted from the foundation-level coaches on the course. The interview focused on course content related to: (i) games-based and drill-based activities, (ii) practice design or structure and (iii) visual scanning or search. The coach educators stated that content on these topics was provided through the formats of the course booklet, coaching practicals, lectures and workshops from specialist external speakers in this area, a secure online website containing the presentations and video practicals, visits from the coach educators to the clubs, and through general discussion and group work at the association headquarters. The consensus of all three coach educators during the interview was that a key aim of the coaching course was to provide information to increase the amount of ADM compared to NDM activities and to increase decision making ability within youth players.

Discussion

The aim of this study is to examine the effectiveness of a coaching course in changing coach behaviour and, subsequently, player skill acquisition. ADM activity was significantly greater in the post-test after the course when compared to the pre-test before it. Additionally, mean NDM activity was lower in the post- compared to the pre-test. The amount of visual scanning in the games and the success rate of ball possessions were significantly greater in the post- compared to the pre-test. Results from the interviews indicated that the main reasons from the coaches for increasing the amount of ADM activity was because of their participation on the coaching course and making their training sessions more game realistic. The content analysis conducted

on the coaching course booklet and resources indicated the importance of using ADM activities and contained many examples of ADM practice activities. Finally, the interviews with the coach educators indicated that a key aim of the coaching course was to provide information to increase the amount of ADM compared to NDM activities and to improve decision making within youth players.

It was hypothesised that the coaching course would advocate and, subsequently, lead to an increased amount of ADM activity in practice sessions occurring after the course compared to before it, with an associated increased amount of visual scanning and successful decision making by players during small-sided games after the course and sessions compared to before it. Our findings support these hypotheses, showing that the amount of ADM activity in practice sessions significantly increased after the coaches completed the coaching course. Additionally, the amount of NDM activity significantly decreased after the coaches completed the coaching course. The amount of ADM activity in the post-test (67% of session time) is greater than that reported by O'Connor et al. in 2017 (41% of session time) and in Study 2 (59% of session time). ADM activity is predicted to lead to greater improvements in the ability of players to use vision to scan the match-play environment and to make decisions when compared to NDM activity (Ford et al., 2010; Williams & Ford, 2013; Low, Williams, McRobert, & Ford, 2013), so an increase in the amount of ADM activity will likely positively affect skill acquisition. An explanation for the increase of ADM activities was provided by the coach participants who stated it was knowledge acquired whilst participating in the coaching course. The FA coaching course advocated increasing the amount of ADM activity used in coaching sessions. Findings showed that the course booklet regularly highlighted the importance of using ADM activities and contained many examples of

ADM practices, with only one example of an NDM activity in the booklet. The importance of decision making and practice structure in youth football was also highlighted throughout the coaching booklet. Furthermore, the interviews with the coach educators indicated that the key aim of the coaching course was to provide information to increase the amount of ADM compared to NDM activities to improve decision making within youth players.

Researchers have investigated the sources of general coaching knowledge (Erickson, Bruner, MacDonald, & Côté, 2008; Wright, Trudel, & Culver, 2007) showing knowledge came from coach education courses, books/videos, and through interacting with coach mentors. Their results support the findings in this study that a coach education course has changed coach behaviour and knowledge through increases in the amount of ADM used after compared to before the course. The main reasons of the coaches for increasing the amount of ADM activity was because of their participation and education on the coaching course. The information in the course allowed them to make their training sessions more game-realistic, attempting to develop the decision making of their players.

Few, if any, researchers have examined the relationship between coaching behaviour and player skill acquisition (Ford et al., 2009). Findings from this study show that the amount of visual scanning and successful decision making in small-sided games was significantly greater after the coaching course when compared with before it. Findings support the prediction (e.g., Ford & Williams, 2013) that ADM activity leads to greater improvements in the ability of players to use vision to scan the match-play environment and to make decisions when compared to NDM activity. The importance of greater amounts of visual scanning and exploratory actions in match-play was highlighted by McGuckian et al. (2018) who showed a higher than average

head turn frequency and head turn excursion before receiving the ball resulted in a greater likelihood of turning with the ball, playing a pass in the attacking direction, and playing a pass to an area that is opposite to which it was received from. Further supporting McGuckian et al. (2018), findings from this research study showed that the number of head turns per minute were significantly greater in the post- compared to the pre-test, whereas the number of ball touches was lower in the post- compared to pre-test. Moreover, there was an associated increase from pre- to post-test in the number of ball possessions per player, with action success also increasing. It appears that greater visual scanning may lead to fewer touches on the ball and an increase in ball possession circulation amongst the team, as indicated by more ball possessions per player and greater action success.

It is important that coaching courses and coaches advocate the use of visual exploratory behaviour as it can have a positive effect on success in soccer performance. Moreover, findings support the idea that content delivered on the coaching courses should lead to a relatively permanent change in coach behaviour that, subsequently, leads to skill acquisition in players (Ford et al, 2009). Furthermore, it must be acknowledged that this study did not include a control group who received no intervention, therefore this may have an impact on the strength of the conclusions drawn because the observed changes may be attributed simply to time playing football.

Chapter 5

Epilogue

This chapter will provide a detailed synthesis of the work presented in the thesis and outline its implications for both theory and practice. The limitations of the work will also be discussed, as well as potential avenues for future research in perceptual-cognitive expertise and coaching.

Aims of the Thesis

The aim of this thesis was to assess and analyse the action execution load of professional soccer players during match-play and evaluate how coaches and coach educators seek to develop these abilities. The aim of Study1 was to quantify and analyse the frequency, type and success of decisions executed as actions in professional soccer players during soccer matches in the English Premier League (EPL), as well as investigating the effect of positional role, time and phase of play. Fifteen professional soccer players representing three home teams during the 2013-2014 season in the EFL (n = 5 players per team) were analysed across three matches per team, totalling 45 observations. Soccer players from each team were equally divided into five positions: centre-back (n = 3), full-back (n = 3), wide-midfield (n = 3), centre-midfield (n = 3), and centre-forward (n = 3). Video footage was analysed for the total frequency and type of every player action execution during the match. Bloomfield et al (2007) revealed that soccer players execute 1,000 to 1,500 movement change during a 90-minute soccer game. Based on this research it was hypothesised that in Study 1 the soccer players would execute 1,500 action executions or more in a 90-minute soccer game. It was expected that centre-midfield players would execute the most actions per match, whereas full-backs would execute the least amount of actions per match (Andrzejewski et al., 2012). Players were expected to execute more actions in the first compared to the second half (Reilly & Thomas, 1976).

The aim of Study 2 was to examine the types of practice activities that coaches have youth soccer players engage in to assess their opportunities for decision making and to investigate the specificity of those activities. Thirty-six soccer coaches and their youth teams took part in this study. There were two child and two adolescent teams from each of three Category 1 English Football Association (FA) Youth Soccer Academies (YSA), three Category 3 FA YSA; and three local recreational football clubs. Three sessions per team were filmed and footage was analysed for the percentage of session time spent in ADM, NDM and transition, as well as measures of practice specificity, including turf used, directional orientation, and size of the activity area. It was expected that the amount of ADM has increased and would be greater than NDM activities when compared to that found in earlier studies (e.g., Ford et al., 2010). Additionally, it was also expected that most training sessions would be practiced on artificial surfaces compared to grass pitches. Furthermore, based on previous research it was predicted that most training sessions would be practiced on small- to medium-sized areas compared to large areas of the soccer pitch.

The aim of Study 3 is to examine the effectiveness of an FA coaching course in changing coach behaviour related to designing practice to increase player decision making during that activity and, subsequently, player skill acquisition and transfer to match-play. We expect the coaching course to advocate and, subsequently, lead to an increased amount of ADM activity in practice sessions occurring after the course compared to before it, with an associated increased amount of visual scanning and better decision making by players during small-sided games after the course and sessions compared to before them.

Summary of Key Findings

Expert team sport players are superior at selecting and executing decisions when compared to lesser-skilled players. However, there is lack of research quantifying the action execution load of team sport players during match-play. Study 1 examined the frequency and type of decision-making in terms of actions executed by professional soccer players during soccer matches. The main overarching finding was that soccer players executed 2,103 actions per match, averaging 21.8 actions per minute. They had 60 ball possessions per match, of which 75% were successfully executed. More actions were executed in the first half compared to the second half. More actions were executed when in possession of the ball and fewer actions were executed when the ball was out of play compared to other phases of play. Positional role did not affect the frequencies of actions executed and ball possessions. However, the number of ball touches was greater for wide-midfielders when compared to centre-backs, with no differences in ball touches between all other playing positions. There were also differences as a function of position for successful ball possessions with centre-midfielders having greater success, compared to centre-backs and centre-forwards.

As demonstrated in Study 1, the action execution load is high during match-play, therefore it is extremely important to design practice that seeks to develop this skill, however our method is not sensitive enough to measure the specific load of each action. One of the main tasks for coaches is to design and lead practice activities for their athletes to improve development and performance. In Study 2, the practice activities used by youth soccer coaches were examined and for the first time the specificity of the practice activities they use was investigated. The amount of ADM activity across age groups was 59% of session time, NDM was 20% of session time, with Transition equating to 21% of session time. Significant differences were found in

ADM activity between age-groups with greater amounts in child compared with adolescent teams. More sessions were performed on artificial surfaces compared to natural grass. More sessions were performed on half a pitch compared to a quarter of a pitch and full pitch, respectively. For directional orientation, the majority of activities had direction towards a goal compared to no direction. The increase in ADM activity compared to previous research is probably due to modern coach education interventions that advocate a greater use of this activity in youth coaching sessions. However, the specificity of those activities was generally relatively low compared to match-play, potentially attenuating transfer effects from practice to match-play.

Active decision making (ADM) activity is expected to lead to greater improvements in the ability of players to use vision to scan the match-play environment and to make decisions when compared to non-active decision making (NDM) activity. In Study 3 the effectiveness of a coaching course in increasing the amount of ADM activity used in youth coaching sessions was examined and the associated effect on visual scanning and decision making by players during small-sided games assessed. ADM activity significantly increased by 18% after compared to before the course, whereas NDM activity significantly decreased by 10%. Coaches cited reasons for this change were their participation on the course, making their training sessions more game-realistic, attempting to develop the decision making of their players, and external reasons, such as the club curriculum. Moreover, after each of the three coaching sessions before and after the course, the players took part in an 8 *vs*. 8 small-sided game that was filmed. Game footage was analysed for the amounts of visual search behaviours and success of decision making. There was significantly more visual scanning and more successful decision making in the games that followed the course compared to before. The course appears to have led to the coaches

increasing the amount of ADM activity they used in their sessions. During the same time period, the visual scanning and decision making of the players improved significantly, probably as a function of the increase in ADM activity following the course, albeit this increase could be associated with engagement in the game across time, rather than the increase in ADM activity.

The previous section has identified and summarised the key findings from Studies 2, 3 and 4. The subsequent section will look at the implication of these findings for theory and practice.

Implications for Theory, Research, and Practice

Several factors deemed important for the study, understanding, and development of expert performance in soccer emerged in this thesis. Study1 highlighted the lack of research quantifying the action execution loads of players during soccer match-play and other team sports. Therefore, the aim of the study was to examine the frequency and type of decision making in terms of actions executed by professional soccer players during soccer matches in the EPL, as well as investigating the effect of positional role, time, and phase of play. The main research finding from Study 1 was that soccer players executed 2,103 (*SD* = 149) actions per match during English Premier League games, averaging 21.8 (*SD* = 1.5) actions per minute. These findings demonstrate the large amount of action executions that occur in the decision-making process during expert soccer match-play performance. In contrast, researchers assessing decision making processes using laboratory-based representative tasks tend to focus on a narrower set of mostly defensive but also offensive situations and decisions (e.g., Williams et al., 1994). Therefore, further research on the nature of decision making in soccer match-play may be needed to inform the design of

representative tasks. Study 1 was the first to assess actions executions in soccer matches, therefore, there is a need for training that actively stimulates the load found in match-play in order to facilitate the transfer of key learning. The training and preparation of players should incorporate decision-making activities that specifically replicate match play to enable them to perform successfully in the future, additionally as shown in Study 1, the action execution load demands are high for all players, however there are specific demands for positional role, as actions across match-play likely involve differing loads or challenges. As shown above, Cognitive Load Theory relates to the amount of information the working memory can hold at one time, therefore is positional role load changes during match-play then it may also be suggested that training should be in part specific to those roles/challenges.

Study 1 highlighted the importance and high frequency of action executions during soccer match play, suggesting that practice should be designed to develop this aspect of performance. One of their main tasks for coaches is designing and leading practice activity for their athletes to improve development and performance, including the action executions assessed in Study 1. In Study 2 the practice activities used by youth soccer coaches in England were assessed for this aspect and for the first time the specificity of the practice activities they use were investigated. The soccer coaching sessions contained 59% of ADM activity, 21% NDM activity and 20% was spent in transition between activities. Significant differences in the use of ADM activity were found between child and adolescent age groups, however there were no significant differences found between academy categories. A contradiction in theory exists between hypotheses (e.g., Davids et al., 2017; Ford et al., 2010) stating that practice for team sports should occur under representative conditions involving ADM when compared to the public competition version of the sport *and* tenets of deliberate

practice theory that hold deliberate practice should be led by a coach for an individual athlete (e.g., Ericsson, 2020). Representative conditions in soccer must involve team practice, but Ericsson (2020) contends that coach-led team practice cannot meet the criteria for deliberate practice, that is, individualized training selected by a coach for an individual athlete. The question is whether coach-led team practice under representative conditions involving ADM can contain the characteristics of deliberate practice.

Team practice certainly appears to improve team and individual performance, and the concept of *specificity* and *representative design* may in part explain why this occurs (Davids et al., 2017; Ford et al., 2010; Ford, 2016). In Study 2 the specificity of team coaching practice activities was investigated for the first time. Findings showed that 89% of sessions were performed on artificial surfaces with only 11% performed on natural grass. Coaches had their players perform in medium practices (half of a pitch) for 41% of the time, 36% in small practices (quarter of a pitch) and 23% of sessions performed in large practices (full pitch). These findings suggest relatively low specificity between these practice activities and match-play in soccer, potentially attenuating transfer effects from practice to match-play. Moreover, some of the ADM activities analysed appeared to lack specificity because players were making movements, actions and decisions that looked and were different to those they make during match-play (Ford, 2016). Coaches should seek to improve specificity during practice activities by increasing the amount of coaching sessions performed on grass and increasing the amount of practice activities on larger scaled football pitches suitable to the age group, which will increase longer range passing and running in-behind the opposition backline (Andersson et al. 2007). It may be that in soccer, given

its complexity, simply practicing and competing in the sport under representative conditions containing ADM leads to performance improvement.

In Study 2, the increase in ADM activity compared to previous research was probably due to modern coach education interventions that advocate a greater use of this activity in youth coaching sessions. Therefore, the aim of Study 3 was to examine the effectiveness of a coaching course in increasing the amount of ADM activity used in youth coaching sessions and the associated effect on the acquisition of visual scanning and decision making by players in small-sided games. Findings revealed that ADM activity significantly increased by 18% after compared to before the course, whereas NDM activity significantly decreased by 10%. Coaches cited reasons for this change were their participation on the course, making their training sessions more game-realistic, attempting to develop the decision making of their players, and external reasons, such as the club curriculum. Whilst this is the first time the sources from which coaches acquire the activities that they use during their sessions has been assessed, other researchers (Erickson et al., 2008; Wright et al., 2007) have investigated general sources of coaching knowledge. Findings in Study 3 of the positive effects of the education course on this aspect of coaching performance contradict conceptions of coaching performance (e.g., Erickson et al., 2008; Wright et al., 2007) mainly being acquired from "doing" coaching and experience. It may be the case that experience and observing other coaches including mentors may form a large part of the coach's performance. However, more formal sources such as coach education courses and printed and electronic material may be a strong influence on changing or adding to their performance. As such, the change from more NDM than ADM activity in youth soccer coaching sessions (e.g., Ford et al., 2010) to more ADM than NDM activity in Study 2 and especially 3 seems to be caused by coach education

courses that advocate this change (professional knowledge). Subsequently, with more coaches who have completed the course scheduling higher amounts of ADM in their sessions it is likely that other coaches informally observing this do the same and the change spreads (craft knowledge).

In Study 3, the increase in ADM occurring from education to coach is supplemented by measurement of the coach effect on player performance before and after the course. In the 8 *vs*. 8 small-sided games before and after the course there was significantly more visual scanning and more successful decision making in the games after compared to before the course. The course appears to have led to the coaches increasing the amount of ADM activity they used in their sessions. During the same time period, the visual scanning and decision making of the players improved significantly, probably as a function of the increase in ADM activity following the course, albeit this increase may simply be associated with engagement in the game across time, rather than the increase in ADM activity. Few, if any, researchers have examined this relationship between coaching intervention and player skill acquisition, but this has been cited a key line for future inquiry (Ford et al., 2009). Moreover, the finding objectively demonstrates "coaching effectiveness" which has debated within coaching and science for many years (e.g., Côté et al., 2007), with some less than reliable methods being used, such as win-loss records (Mallet & Côté, 2006) or the status and experience of the coach.

Across studies this thesis has shown that decision-making as action executions is a key component of player performance in match-play and coaches now provide many activities for their youth players to acquire this component, with coach educators advocating this on their courses, leading to more widespread use of those activities and players acquiring this component.

Limitations and Directions for Future Research

The research in Study 1 aimed to examine the frequency and types of decision-making in terms of action executions performed by professional soccer players during competitive matches. This type of data collection is novel within research, so it was difficult to draw comparisons on other methodologies. Although the purpose of this research study was to solely look at the amount of action executions that professional soccer players perform and understand roles, findings may not be generalisable to other contexts. For example, understanding the different amounts of action executions between a lesser skilled group (novices) and professional soccer players would be an area to investigate in the future. As well as novices being analysed, it would be interesting to analyse soccer players from different leagues to identify if there are any significant differences between action execution loads, including female players. Additionally, future research should assess how the action execution load may differ across shorter time periods (early stages of the game *vs*. the latter stages), as tactics evolve across time, and how the action execution load differs for individuals 10 years ago playing full-back compared to now (Fernandez-Navarro, Fradua, Zubillaga & McRobert, 2019; Fernandez-Navarro, Fradua, Zubillaga & McRobert, 2018). Wide angle footage was used to collect the data in Study 1, but if we were to collate and analyse other perceptual cognitive skills, such as visual scanning, it would be most beneficial to use "player cam" footage.

In Study 2 the practice activities used by elite youth soccer coaches in England were assessed. A limiting factor of this research is that the intentions of the coach for each practice bout were not measured. For example, coaches may have identified the need for and had their players practicing passing with their weaker foot in a technical drill with no opposition, which would be categorised as NDM and not beneficial to

developing decision making. Additionally, the planning of the coaches for the season and beyond was not recorded, so the activities measured were just a "snap shot" of a certain time in the season. In future, researchers should aim to conduct longitudinal studies in order to capture a more comprehensive data set involving the planning and intentional process of the coaches leading the activity and the effects of the practice on skill acquisition. Moreover, in future, researchers will have to resolve the contradiction that exists between hypotheses (e.g., Davids et al., 2017; Ford et al., 2010) stating that practice for team sports should occur under representative conditions involving ADM *and* tenets of deliberate practice theory stating that activity must be led by a coach for an individual athlete (e.g., Ericsson, 2020). Such research will have to assess the aspect of performance chosen to practice in a team sport and the process that leads to it, as well the individualisation and evaluation processes that occur during and after practice, respectively.

In Study 2 there is no measurement of learning and skill acquisition of the athletes following the practice activities, which is typical of this type of research (Ford et., 2010; Low et al., 2013) leaving the effects of ADM and lower specificity untested. However, in Study 3 the effects of the practice activities on player skill acquisition were measured and future research should use this method (for a review, see Ford et al., 2009). Furthermore, Study 3 aimed to assess the effectiveness of a coaching course in increasing the amount of ADM activity used in youth coaching sessions and the associated effect of any change to coach behaviour on visual scanning and decision making by players during small-sided games. The main limitation of this research study was that a longitudinal analysis was required to measure whether the coaches maintained the level of ADM activity found in the post-test and future research should consider this study design.

Conclusion

The aim of the thesis was to assess and analyse the action execution load of professional soccer players during match-play and evaluate how coaches and coach educators seek to develop these abilities. Soccer players executed 2,103 actions per match during English Premier League soccer games, averaging 21.8 actions per minute. Findings demonstrate the key role of action executions during expert soccer match-play performance. There are implications for practice design so that training actively stimulates the load found in match-play to facilitate the transfer of learning. In Study 2, soccer coaching sessions contained a greater amount of ADM activities compared to NDM activities. Coaches mainly had their players perform in medium practices compared to smaller and larger ones. A greater amount of coaching sessions had direction towards a goal, with the majority of sessions performed on artificial surfaces. Practical implications are that coaches should seek to further increase the amount of ADM activity. Moreover, some of the ADM activities analysed lacked representativeness and specificity because the conditions differ and because players were making movements, actions and decisions that looked and were different to those they make during match-play. Coaches should seek to increase the amount of specificity during practice activities by increasing the number of coaching sessions performed on grass and increasing the amount of practice activities on larger-sized football pitches appropriate to that age group. In Study 3, the amount of ADM activity significantly increased after the coaches completed the coaching course where this was advocated. The coaches stated the reasons for this increase in ADM were due to the knowledge acquired on the coaching course. Additionally, the amount of visual scanning and successful decision making in small-sided games was

significantly greater after the course compared to before it. Findings from this study support the idea that content delivered on the coaching course should lead to a relatively permanent change in coach behaviour that, subsequently leads to skill acquisition. This thesis has shown that decision making is a key component of player performance in match-play and coaches now provide many activities for their youth players to acquire this component, with coach educators advocating this on their courses, leading to more widespread use of those activities and players acquiring this component.

Chapter 6

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Chapter 7

Appendix

List of Publications

Ford, P. R, & Whelan, J. (2016). Practice activities during coaching sessions in elite youth football and their effect on skill acquisition. In W. Allison., A. Abraham & A. Cale (Eds.), *Advances in coach education and development: From research to practice* (pp. 112-123). London, LN: Routledge.